the first sample ($\overline{X}_1$) is equal to or greater than the lower control limit (LCL_1), the basic model is in compliance and testing is at an end.

(ii) If the value of n is greater than n_1, the basic model is in non-compliance. The size of a second sample n_2 is determined to be the smallest integer equal to or greater than the difference $n - n_1$. If the value of n_2 so calculated is greater than $20 - n_1$, set n_2 equal to $20 - n_1$.

Step 8. Compute the combined mean ($\overline{X}_2$) of the measured energy performance of the n_1 and n_2 units of the combined first and second samples as follows:

$$\overline{X}_2 = \frac{1}{n_1 + n_2} \sum_{i=1}^{n_1+n_2} X_i \qquad (6)$$

Step 9. Compute the standard error ($SE(\overline{X}_2)$) of the mean full-load efficiency of the n_1 and n_2 units in the combined first and second samples as follows:

$$SE(\overline{X}_2) = \frac{S_1}{\sqrt{n_1 + n_2}} \qquad (7)$$

(Note that S_1 is the value obtained above in Step 3.)

Step 10. Set the lower control limit (LCL_2) to,

$$LCL_2 = RE - tSE(\overline{X}_2) \qquad (8)$$

where t has the value obtained in Step 5, and compare the combined sample mean ($\overline{X}_2$) to the lower control limit (LCL_2) to find one of the following:

(i) If the mean of the combined sample ($\overline{X}_2$) is less than the lower control limit (LCL_2), the basic model is in non-compliance and testing is at an end.

(ii) If the mean of the combined sample ($\overline{X}_2$) is equal to or greater than the lower control limit (LCL_2), the basic model is in compliance and testing is at an end.

MANUFACTURER-OPTION TESTING

If a determination of non-compliance is made in Steps 6, 7 or 10, above, the manufacturer may request that additional testing be conducted, in accordance with the following procedures.

Step A. The manufacturer requests that an additional number, n_3, of units be tested, with n_3 chosen such that $n_1 + n_2 + n_3$ does not exceed 20.

Step B. Compute the mean full-load efficiency, standard error, and lower control limit of the new combined sample in accordance with the procedures prescribed in Steps 8, 9, and 10, above.

Step C. Compare the mean performance of the new combined sample to the lower control limit (LCL_2) to determine one of the following:

(a) If the new combined sample mean is equal to or greater than the lower control limit, the basic model is in compliance and testing is at an end.

(b) If the new combined sample mean is less than the lower control limit and the value of $n_1 + n_2 + n_3$ is less than 20, the manufacturer may request that additional units be tested. The total of all units tested may not exceed 20. Steps A, B, and C are then repeated.

(c) Otherwise, the basic model is determined to be in non-compliance.

PART 435—ENERGY CONSERVATION VOLUNTARY PERFORMANCE STANDARDS FOR NEW BUILDINGS; MANDATORY FOR FEDERAL BUILDINGS

Subpart A—Voluntary Performance Standards for New Commercial and Multi-Family High Rise Residential Buildings; Mandatory for Federal Buildings

Subpart B—Voluntary Performance Standards for New Non-Federal Residential Buildings [Reserved]

Subpart C—Mandatory Performance Standards for New Federal Residential Buildings

AUTHORITY: 42 U.S.C. 6831–6870; 42 U.S.C. 8254; 42 U.S.C. 7101, *et seq.*

SOURCE: 53 FR 32545, Aug. 25, 1988, unless otherwise noted.

Subpart A—Voluntary Performance Standards for New Commercial and Multi-Family High Rise Residential Buildings; Mandatory for Federal Buildings

SOURCE: 54 FR 4554, January 30, 1989, unless otherwise noted.

§ 435.97 Purpose.

(a) This subpart establishes energy conservation voluntary performance standards for the design of new commercial and multi-family high rise residential buildings. The voluntary performance standards are designed to achieve the maximum practicable improvements in energy efficiency and increases in the use of non-depletable sources of energy.

(b) The voluntary performance standards will be used by Federal agencies for the design of new Federal commercial and multi-family high rise residential buildings.

(c) Except in the case of new commercial and multi-family high rise residential buildings, which are Federal buildings, voluntary performance standards prescribed under this subpart are developed solely as guidelines for the purpose of providing technical assistance for the design of energy efficient buildings.

§ 435.98 Scope.

(a) The voluntary performance standards for new commercial and multi-family high rise residential buildings apply to the design of a new commercial or multi-family high rise residential building, except for the following:

(1) A building constructed and developed for residential occupancy, unless the building is a multi-family high rise residential building with 3 or more stories;

(2) Heating, cooling, ventilating, or service hot water requirements for those spaces where processes occur for purposes other than occupant comfort and sanitation, and which impose thermal loads in excess of 5% of the loads that would otherwise be required for occupant comfort and sanitation without the process;

(3) Envelope requirements for those spaces where heating or cooling requirements are excepted in paragraph (a)(2) of this section;

(4) Lighting for tasks not listed or encompassed by areas or activities listed in Table 3.5–1; and

(5) Buildings that are composed entirely of spaces listed in paragraphs (a) (2), (3), and (4) of this section.

§ 435.99 General definitions and acronyms.

(a) For the purpose of this subpart:

Accessible (as applied to equipment) means admitting close approach; not guarded by locked doors, elevation, or other effective means. (See also *Readily Accessible*.)

Adjusted Lighting Power means lighting power, ascribed to a luminaire(s), that has been reduced by deducting a lighting power control credit based on use of an automatic control device.

Annual Fuel Utilization Efficiency means the ratio of annual output energy to annual input energy that includes any non-heating season pilot input loss.

Air Conditioning, Comfort means treating air to control its temperature, relative humidity, cleanliness, and distribution to meet the comfort requirements of the occupants of the conditioned space. Some air conditioners may not accomplish all of these controls.

Ambient Lighting means lighting that produces general illumination throughout an area.

Area Factor means a multiplying factor that adjusts the base unit power density (UPD) for spaces of various sizes to account for the impact of room configuration on lighting power utilization.

Automatic means a self-acting, operating by its own mechanism, when actuated by some impersonal influence, such as, a change in current strength, pressure, temperature or mechanical configuration. (See also *Manual*.)

Ballast means a device used with an electric-discharge lamp to obtain the necessary circuit conditions (voltage, current, and wave form) for starting and operating.

Ballast Efficacy Factor—Fluorescent means the ratio of the relative light output to the power input in watts, at specified test conditions, expressed as a percent.

Ballast Factor means the ratio of a commercial ballast lamp lumens to a reference ballast lamp lumens, used to correct the lamp lumen output from rated to actual.

Boiler Capacity means the rated heat output in Btu/h of the boiler, at the design inlet and outlet conditions and rated fuel/energy input.

British Thermal Unit means approximately the amount of heat required to raise the temperature of one pound of water from 59 °F to 60 °F.

Building means any new structure to be constructed that includes provision for a heating or cooling system, or both, or for a hot water system.

Building Code means a legal instrument which is in effect in a state or unit of general purpose local government, the provisions of which must be adhered to if a building is to be considered to be in conformance with law and suitable for occupancy and use.

Building Design means the architectural and engineering drawings and specifications used for the construction of a new building.

Building Energy Cost means the computed annual energy cost of all purchased energy for the building, calculated using the methods of section 435.111 of these standards.

Building Envelope means the elements of a building that enclose conditioned spaces through which thermal energy may be transferred to or from the exterior or to or from unconditioned spaces.

Building Type means the classification of a building by usage. In this regulation the following classifications of buildings are defined by these uses:

(1) *Assembly* means a building or structure for the gathering together of persons, such as auditoriums, churches, dance halls, gymnasiums, theaters, museums, passenger depots, sports facilities, and public assembly halls.

(2) *Health and Institutional* means a building or structure for the purpose of providing medical treatment, confinement or care, and sleeping facilities such as hospitals, sanitariums, clinics, orphanages, nursing homes, mental institutions, reformatories, jails, and prisons.

(3) *Hotel/Motel* means a building or structure for transient occupancy, such as resorts, hotels, motels, barracks, and dormitories.

(4) *Multi-Family* means a building or structure containing three or more dwelling units. (See *Dwelling Units*, and *Multi-Family Dwelling*.)

(5) *Office (Business)* means a building or structure for office, professional, or service type transactions, such as medical offices, banks, libraries, and business offices, including governmental office buildings.

(6) *Restaurant* means a building or a structure for the consumption of food or drink, including fast food, coffee shops, cafeterias, bars, and restaurants.

(7) *Retail (Mercantile)* means a building or a structure for the display and sale (wholesale or retail) of merchandise, such as shopping malls, food markets, auto dealerships, department stores, and specialty shops. (See also *Retail Establishments*.)

(8) *School (Educational)* means a building or structure for the purpose of instruction, such as schools, colleges, universities, and academies.

(9) *Warehouse (Storage)* means a building or structure for storage, such as aircraft hangers, garages, warehouses, storage buildings, and freight depots.

Check Metering means measurement instrumentation for the supplementary monitoring of energy (electric, gas, oil, etc.) consumption, in addition to the revenue metering furnished by the utility, to isolate the various categories of energy use to permit conservation and control.

Coefficient of Performance—Cooling means the ratio of the rate of heat removal to the rate of energy input in consistent units, for a complete cooling system or factory assembled equipment, as tested under a nationally recognized standard or designated operating conditions.

Coefficient of Performance, Heat Pump—Heating means the ratio of the rate of heat delivered to the rate of energy input, in consistent units, for a complete heat pump system under designated operating conditions. When checking compliance with the heat pump equipment COP's listed in the tables in section 435.108.

Combined Thermal Transmittance Values (See *Thermal Transmittance, Overall*.)

Commercial Building means a building other than a residential building, including any building developed for industrial or public purposes.

Conditioned Floor Area means the area of the conditioned space measured at floor level from the interior surfaces of the walls.

Conditioned Space means a volume within a building that is designed to be heated and/or cooled, directly or indirectly.

Connected Lighting Power means the power required to energize luminaires and lamps installed and connected to the building electrical service, in watts.

Control Loop, Local means a control system consisting of a sensor, a controller, and a controlled device.

Cooled Space means an enclosed area within a building that has a refrigeration system whose sensible capacity exceeds 5 Btu/h•ft^2 or is capable of maintaining space dry bulb temperatures of 90 °F or less at design cooling conditions.

Daylight Sensing Control means a device that automatically regulates the power input to electric lighting near the fenestration to maintain the desired workplace illumination, thus taking advantage of direct or indirect sunlight.

Dead Band (Dead Zone) means the range of values within which an input variable can be varied without initiating any noticeable change in the output variable.

Default Assumption means the value of an input used in a calculation procedure when a value is not entered by the designer.

Degree-Day means a unit, based upon temperature difference and time, used in estimating fuel consumption and specifying nominal heating load of building in winter. For any day, when the mean temperature is less than a reference temperature, typically 65 °F, there are as many Degree-Days as Fahrenheit degrees difference in temperature between the mean temperature for the day and the reference temperature.

Degree Day, Cooling means a unit, based upon temperature difference and time, used in estimating cooling energy consumption. For any one day, when the mean temperature is more than a reference temperature, typically 65 °F, there are as many Degree Days as degrees Fahrenheit temperature difference between the mean temperature for the day and the reference temperature. Annual Cooling Degree Days (CDD) are the sum of the degree days over a calendar year.

Degree Day, Heating means a unit, based upon temperature difference and time, used in estimating heating energy consumption. For any one day, when the mean temperature is less than a reference temperature, typically 65 °F, there are as many Degree Days as degrees Fahrenheit temperature difference between the mean temperature for the day and the reference temperature. Annual Heating Degree Days (HDD) are the sum of the degree days over a calendar year.

Demand (Electric) means the rate at which electric energy is delivered to or by a system, part of a system, or a piece of equipment; expressed in kilowatts, kilovoltamperes; or other suitable units at a given instant or averaged over any designated period.

Design Conditions means the exterior and interior environmental parameters specified for air conditioning and electrical design for a facility.

Design Energy Consumption means the computed annual energy usage of a proposed building design.

Design Energy Costs means the computed annual energy expenditures of a proposed building design.

Dwelling Unit means a single housekeeping unit comprised of one or more rooms providing complete, independent living facilities for one or more persons including permanent provisions for living, sleeping, eating, cooking, and sanitation.

Economizer, Air means a ducting arrangement and automatic control system that allows a cooling supply fan system to supply outside air to reduce or eliminate the need for mechanical refrigeration during mild or cold weather.

Economizer, Water means a system by which the supply air of a cooling system is cooled directly and/or indirectly by evaporation of water, or by other appropriate fluid, in order to reduce or eliminate the need for mechanical refrigeration.

Efficiency, HVAC System means the ratio of the useful energy output (at the point of use) to the energy input in consistent units for a designated time period, expressed in percent.

Emergency System (Back Up System) means a system which exists for the purpose of operating in the event of failure of a primary system.

Energy means the capability for doing work; having several forms that may be transformed from one to another, such as thermal (heat), mechanical (work), electrical, and chemical.

Energy Cost means the annual cost of energy by unit and type of energy.

Energy Cost Budget means the maximum allowable computed annual energy expenditure for a proposed building.

Energy Efficiency Ratio means the ratio of net equipment cooling capacity in Btu/h to total rate of electric input in watts under designated operating conditions. When consistent units are used, this ratio becomes equal to COP. (See also *Coefficient of Performance*.)

Energy Management System means a control system designed to monitor the environment and the use of energy in a facility and to adjust the parameters of local control loops to conserve energy while maintaining a suitable environment.

Energy, Recovered (See *Recovered Energy*.)

Enthalpy means a thermodynamic property of a substance defined as the sum of its internal energy plus the quantity PV/J, where P=pressure of the substance, V=its volume, and J=the mechanical equivalent of heat; formerly called total heat and heat content.

Exterior Envelope (See *Building Envelope*.)

Fenestration means any light-transmitting section in a building wall or roof. The fenestration includes glazing material, which may be glass or plastic; framing, mullions, muntins, and dividers; external shading devices; internal shading devices, and integral (between-glass) shading devices.

Federal Agency means any department, agency, corporation, or other entity or instrumentality of the executive branch of the Federal Government, including the United States Postal Service, the Federal National Mortgage Association, and the Federal Home Loan Mortgage Corporation.

Federal Building means any building to be constructed by, or for the use of, any Federal Agency which is not legally subject to State or local building codes or similar requirements.

Footcandle means the unit of illuminance on a surface one square foot in area on which there is a uniformly distributed flux of one lumen, or the illuminance produced on a surface all points of which are at a distance of one foot from a directionally uniform point source of one candela.

General Lighting means lighting designed to provide illumination throughout an area, exclusive of any provision for special local requirements.

Gross Floor Area means the sum of the areas of the several floors of the building, including basements, mezzanine and intermediate-floored tiers and penthouses of headroom height, measured from the exterior faces of exterior walls or from the centerline of walls separating buildings, but excluding covered walkways, open roofed-over areas, porches and similar spaces, pipe trenches, exterior terraces or steps, chimneys, roof overhangs, and similar features.

Gross Lighted Area means the sum of the total lighted areas of a building measured from the inside of the perimeter walls, for each floor of the building.

Gross Roof Area means the total surface of the roof assembly exposed to the outside air, including all roof/ceiling and skylight components through which heat may flow between indoor and outdoor environments, excluding service openings.

Gross Exterior Wall Area means the total surface of the wall assembly exposed to the outside air and enclosing a heated or cooled space consisting of opaque surfaces, including between floor spandrels, peripheral edges of flooring and window areas including sash and door areas but excluding vents, grilles, and pipes.

HVAC System means the equipment distribution network and terminals that provide either collectively or individually the processes of heating, ventilating, and/or air conditioning to a building.

HVAC System Efficiency (See *Efficiency, HVAC System*.)

Heat means the form of energy that is transferred by virtue of a temperature difference or a change in state of a material.

Heat Capacity means the amount of heat necessary to raise the temperature of a given mass one degree. Numerically the mass multiplied by the specific heat.

Heated Space means a volume within a building which is provided with a positive supply of thermal energy by a system whose output capacity either exceeds 10 Btu/h•ft^2 or is capable of maintaining a space dry-bulb temperature of 50 °F or more at design building conditions.

Heating System Performance Factor means the total heating output of a heat pump during its normal annual usage period for heating, in Btu, divided by the total electric energy input during the same period, in watt-hours.

Heat Trap means a device coupled to the inlet and outlet of a water heater that effectively restricts the natural tendency of hot water to rise in the vertical pipe during periods of standby.

Humidistat means an automatic control device responsive to changes in humidity.

Illuminance means the density of the luminous flux incident on a surface. It is the quotient of the luminous flux multiplied by the area of the surface when the latter is uniformly illuminated. (See also *Footcandle*.)

Industrial Process means any manufacturing or other process whose energy requirements are not primarily intended to contribute to the heating, cooling, lighting, ventilation, or service hot water energy load requirements of the building.

Infiltration means the uncontrolled inward air leakage through cracks and crevices in any building element and around windows and doors of a building.

Insolation means the rate of solar energy incident on a unit area with a given orientation.

Integrated Part-Load Value means a single number figure of merit for airconditioning and heat pump equipment based on weighted operation at a set of less than full capacities for the equipment.

Lighting Power Budget means the lighting power, in watts, allowed for an interior or exterior area or activity.

Lighting Power Control Credit means the amount of interior connected lighting power which may be added to the Interior Lighting Power Allowance for lights in a space which is turned off or dimmed by automatic control devices.

Lumen means SI unit of luminous flux. Radiometrically, it is determined from the radiant power. Photometrically, it is the luminous flux emitted within a unit solid angle (one steradian) by a point source having a uniform luminous intensity of one candela.

Lumen Maintenance Control means a device that senses the illumination level and causes an increase/decrease of illuminance to maintain a preset illumination level.

Luminaire means a complete lighting unit consisting of a lamp or lamps together with the parts designed to distribute the light, to position and protect the lamps, and to connect the lamps to the power supply.

Luminaire Efficiency means the ratio of luminous flux (lumens) emitted by a luminaire to that emitted by the lamp or lamps used therein.

Manual (Non-Automatic) means action requiring personal intervention for its control. As applied to an electric controller, non-automatic control does not necessarily imply a manual controller, but only that personal intervention is necessary. (See *Automatic*.)

Marked Rating means the design load operating conditions of a device as shown by the manufacturer on the nameplate or otherwise marked on the device.

Minimum Life Cycle Cost Methodology means the methodology specified in subpart A of 10 CFR part 436.

Motor Efficiency, Nominal means the median efficiency occurring in a population of motors of the same manufacturer and rating.

Multi-Family High Rise Residential Building means a residential building containing three or more dwelling units and is designed to be 3 or more stories above grade.

Multi-Family Low Rise Residential Building means a residential building containing three or more dwelling units and is designed not to exceed two stories above grade.

Non-Depletable Energy Sources means sources of energy, excluding minerals, derived from incoming solar radiation; thermal chemical or electrical energy derived directly from conversion of incident solar radiation; wind, waves and tides, lake, or pond thermal differences; and energy derived from the internal heat of the earth.

Occupancy Sensor means a device that detects the presence or absence of people within an area and causes lighting, equipment, and/or appliances to be adjusted accordingly.

Opaque Areas means all exposed areas of a building envelope which enclose conditioned space, except fenestration areas and building service openings, such as vents, grilles, and pipes.

Orientation means the directional placement of a building on a building site with reference to the building's longest horizontal axis, or, if none, with reference to the designated main entrance.

Outdoor (Outside) Air means air taken from the exterior of the building that has not been previously circulated through the building. (See also *Ventilating Air*.)

Ozone Depletion Factor means a relative measure of the potency of chemicals in depleting stratospheric ozone. The ozone depletion factor potential depends upon the chlorine and the bromine content and atmospheric lifetime of the chemical. The depletion factor potentials are normalized such that the factor for CFC–11 is set equal to unity and the factors for the other chemicals indicate their potential relative to CFC–11.

Packaged Terminal Air-Conditioner means a factory-selected wall sleeve and separate unencased combination of heating and cooling components, assemblies or sections, intended for mounting through the wall to serve a single room or zone. It includes heating capability by hot water, steam, or electricity.

Packaged Terminal Heat Pump means a PTAC capable of using the refrigeration system in a reverse cycle or heat pump mode to provide heat.

Piping means a system for conveying fluids, including pipes, valves, strainers, and fittings.

Plenum means an enclosure that is part of the air handling system and is distinguished by having a very low air velocity. A plenum often is formed in part or in total by portions of the building.

Power means, in connection with machines, the time rate of doing work; in connection with the transmission of energy of all types, the rate at which energy is transmitted; in inch-pound units, is measured in watts (W) or British thermal units per hour (Btu/h).

Power Adjustment Factor means a modifying factor that adjusts the effective connected lighting power of a space to account for the use of energy conserving lighting control devices.

Power Factor means the ratio of total watts to the root-mean-square (RMS) volt amperes.

Prescribed Assumption means a fixed value of an input to the standard calculation procedure.

Process Energy means energy consumed in support of a manufacturing, industrial, or commercial process, other than the maintenance of comfort and amenities for the occupants of a building.

Process Load means the calculated or measured time-integrated load on a building resulting from the consumption or release of process energy.

Proposed Design means a prospective design for a building that is to be evaluated for compliance.

Prototype Building means a generic building design of the same size and occupancy type as the proposed design, which complies with the prescriptive requirements of the standards and has prescribed assumptions used to generate the energy budget concerning shape, orientation, HVAC, and other system designs.

Public Facility Restroom means a restroom used by the transient public.

Radiant Comfort Heating means a system in which temperatures of room surfaces are adjusted to control the rate of heat loss by radiation from occupants.

Readily Accessible means capable of being reached quickly for operation, renewal, or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, chairs, and so on. (See also *Accessible*.)

Recooling means lowering the temperature of air that has been previously heated by a heating system.

Recovered Energy means energy utilized which would otherwise be wasted (not contributing to a desired end use) from an energy utilization system.

Reference Building means a specific building design that has the same form, orientation and basic systems as the proposed design and meets all the criteria of the prescriptive compliance method.

Reflectance means the ratio of the light reflected by a surface to the light incident upon it.

Reheating means raising the temperature of air that has been previously cooled either by a refrigeration or an economizer system.

Reset means adjustment of the controller set point to a higher or lower value automatically or manually.

Residential means any structure which is constructed and developed for residential occupancy.

Retail Establishments means, for the purpose of determining lighting power limit, buildings, the primary functions of which are designed to be:

(1) Type A—Jewelry Merchandising, where the minute display and examination of merchandise is critical.

(2) Type B—Fine Merchandising: Fine apparel and accessories, china, crystal and silver, art galleries, etc., where the detailed display and examination of merchandise is important.

(3) Type C—Mass Merchandising, where focused display and detailed examination of merchandise is important.

(4) Type D—General Merchandising: General apparel, variety, stationery, books, sporting goods, hobby, cameras, gift, luggage, etc., where general display and examination of merchandise are adequate.

(5) Type E—Food & Miscellaneous: Bakeries, hardware and housewares, grocery, appliances and furniture, etc., where appetizing appearance is important.

(6) Type F—Service Establishments, where functional performance is important.

Roof means those portions of the building envelope including all opaque surfaces, fenestration, doors, and hatches which are above conditioned space and which are horizontal or tilted at less than 45° from horizontal. (See also *Walls*.)

Room Air Conditioner means an encased assembly designed as a unit to be mounted in a window or through a wall, or as a console. It is designed primarily to provide free delivery of conditioned air to an enclosed space, room, or zone. It includes a prime source of refrigeration for cooling and dehumidification and means for circulating and cleaning air, and may also include means for ventilating and heating.

Seasonal Energy Efficiency Ratio means the total cooling output of an air conditioner during its normal annual usage period for cooling, in Btu/h, divided by the total electric energy input during the same period, in watt-hours, as determined by 10 CFR, part 430.

Service Systems means all energy-using or distributing components in a building that are operated to support the occupant or process functions housed therein, including HVAC, service water heating, illumination, transportation, cooking or food preparation, laundering or similar functions.

Service Water Heating means the supply of hot water for purposes other than comfort heating and process requirements.

Service Water Heating Demand means the maximum design rate of water withdrawal from a service water heating system in a designated period of time (usually an hour or a day).

Shading Coefficient means the ratio of solar heat gain through fenestration, with or without integral shading devices, to that occurring through unshaded ⅛ inch thick clear, double strength glass.

Shell Building means a building for which the envelope is designed and/or constructed prior to knowing the occupancy type. (See also *Speculative Building*.)

Speculative Building means a building for which the envelope is designed and/or constructed prior to the design of the lighting and/or HVAC systems. A speculative building differs from a shell building in that the intended occupancy is known for the speculative building. (See also *Shell Building*.)

Standard Calculation Procedure means an energy simulation model, and a set of input assumptions, that produce estimates of annual energy consumption for heating, cooling, ventilation, lighting, and other uses and that account for the dynamic thermal performance of the building.

System means a combination of equipment and/or controls, accessories, interconnecting means, and terminal elements by which energy is transformed so as to perform a specific function, such as HVAC, service water heating, or illumination.

Tandem Wiring means pairs of luminaires operating with one lamp in each luminaire powered from a single two-lamp ballast contained in the other luminaire.

Task Lighting means lighting that provides illumination for specific visual functions and is directed to a specific surface or area.

Task Location means an area of the space where significant visual functions are performed and where lighting is required above and beyond that required for general ambient use.

Terminal Element means a device by which the transformed energy from a system is finally delivered; *i.e.*, registers, diffusers, lighting fixtures, faucets, etc.

Thermal Conductance means the constant time rate of heat flow through unit area of a body induced by a unit temperature difference between the surfaces, Btu/ft^2•h•°F or Btu/h•°F. It is reciprocal of thermal resistance. (See *Thermal Resistance*.)

Thermal Mass means materials with mass heat capacity and surface area capable of affecting building loads by storing and releasing heat as the interior and/or exterior temperature and radiant conditions fluctuate. (See also *Wall Heat Capacity*.) Thermal Mass Wall Insulation Position:

(1) *Exterior Insulation Position* means a wall having all or nearly all of its mass exposed to the room air with the insulation on the exterior of that mass.

(2) *Integral Insulation Position* means a wall having mass exposed to both room and outside air, with substantially equal amounts of mass on the inside and outside of the insulation layer.

(3) *Interior Insulation Position* means a wall not meeting either of the above definitions, particularly a wall having most of its mass external to an insulation layer.

Thermal Resistance means the reciprocal thermal conductance; 1/C as well as 1/h, 1/U, h•ft^2•°F/Btu.

Thermal Transmittance means the overall coefficient of heat transfer from air to air. It is the time rate of heat flow per unit area under steady conditions from the fluid on the warm side of the barrier to the fluid on the cold side, per unit temperature difference between the two fluids, Btu/h•ft^2•°F.

Thermal Transmittance, Overall means the gross overall (area weighted average) coefficient of heat transfer from air to air for a gross area of the building envelope, Btu/h•ft^2•°F. The thermal transmittance (U°) value applies to the combined effect of the time rate of heat flows through the various parallel paths, such as windows, doors, and opaque construction areas, comprising the gross area of one or more building envelope components, such as walls, floors, or roof/ceiling.

Thermostat means an automatic control device responsive to temperature.

Unconditioned Space means a volume within a building that is not designed to be directly or indirectly heated and/or cooled. (See *Conditioned Space*.)

Unit Power Density means the floor area designated for a specific occupancy, function, or activity expressed in W/ft^2.

Unitary Cooling Equipment means one or more factory-made assemblies which normally include an evaporator or cooling coil, a compressor and condenser combination, and may include a heating function as well.

Unitary Heat Pump means one or more factory-made assemblies which normally include an indoor conditioning coil, compressor(s) and outdoor coil or refrigerant-to-water heat exchanger, including means to provide both heating and cooling functions.

Unlisted Space means the difference in area between the gross lighted area and the sum of all listed spaces.

Variable Air Volume (VAV) HVAC System means HVAC systems that control the dry-bulb temperature within a space by varying the volume of supply air to the space.

Ventilation means the process of supplying or removing air by natural or mechanical means to or from any space. Such air may or may not have been conditioned.

Ventilation Air means that portion of supply air which comes from outside (outdoors) plus any recirculated air that has been treated to maintain the desired quality of air within a designated space. (See also *Outdoor Air*.)

Visual Task means those details and objects that must be seen for the performance of a given activity, and includes the immediate background of the details or objects.

Voluntary Performance Standards means an energy consumption goal or goals to be met without specification of the method, materials, and processes to be employed in achieving that goal or goals, but including statements of the requirements, criteria and evaluation methods to be used, and any necessary commentary.

Walls means those portions of the building envelope enclosing conditioned space including all opaque surfaces, fenestration and doors, which are vertical or tilted at an angle of 45° from horizontal or greater. (See also *Roof*.)

Wall Heat Capacity means the sum of the products of the mass of each individual material in the wall per unit area of wall surface times its individual specific heat, Btu/F. (See *Thermal Mass*.)

Watt means a unit of power. One watt is produced when one ampere, flows at an amp of one volt (unity power factor). (See also *Power*.)

Zone means a space or group of spaces within a building with heating, cooling, and/or lighting requirements sufficiently similar so that desired conditions can be maintained throughout by a single controlling device.

(b) For definitions not found in paragraph (a) of this section, the 1986 edition of ''Terminology of Heating and Ventilation, Air-Conditioning, and Refrigeration'' as published by the American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc. (ASHRAE) shall apply to these standards.

(c) For purposes of this subpart, the acronyms and abbreviations shall have the following meanings:

A_o—Total Building Floor Area.

$A_{wall,roof,etc.}$—Area of a Specific Building component.

AAMA—American Aluminum Manufacturers Association.

ACP—Alternative Component Package.

AF—Area Factor.

AFUE—Annual Fuel Utilization Efficiency.

AHAM—Association of Home Appliance Manufacturers.

ALP—Adjusted Lighting Power.

ANSI—American National Standards Institute.

ARI—Air-Conditioning and Refrigeration Institute.

ASHRAE—American Society of Heating, Refrigeration and Air Conditioning Engineers, Inc.

ASME—American Society of Mechanical Engineers.

ASTM—American Society for Testing and Materials.

Btu—British Thermal Unit.

Btu/h—British Thermal Units Per Hour.

C—Thermal Conductance.

C_c—Cooling Criteria.
CDD—Cooling Degree-Days.
CDD50—Cooling Degree-Days Base 50 °F.
CDD65—Cooling Degree-Days Base 65 °F.
CDH—Cooling Degree-Hours.
CDH80—Cooling Degree-Hours Base 80 °F.
CEEU—Cost Equivalent Energy Units.
cfm—Cubic Feet Per Minute.
CFR—Code of Federal Regulations.
CLP—Connected Lighting Power.
COP—Coefficient of Performance.
CU—Coefficient of Utilization.
DOE—U.S. Department of Energy.
DR—Average Daily Temperature Range for Warmest Month.
EER—Energy Efficiency Ratio.
ELPA—Exterior Lighting Power Allowance.
EPD—Equipment Power Density.
° F—Degrees-Fahrenheit
GLA—Gross Lighted Building Area.
HC—Heat Capacity.
HDD—Heating Degree-Days.
HDD50—Heating Degree-Days Base 50 °F.
HDD65—Heating Degree-Days Base 65 °F.
HI—Hydronics Institute.
HID—High Intensity Discharge.
hp—Horsepower (force).
HPS—High Pressure Sodium.
HSPF—Heating System Performance Factor.
HVAC—Heating, Ventilating and Air Conditioning.
IEEE—Institute of Electrical and Electronics Engineers, Inc.
IES—Illuminating Engineering Society of North America.
ILPA—Interior Lighting Power Allowance.
IPLV—Integrated Part Load Value.
ILD—Internal Load Density.
IRF—Internal Reflecting Film.
ISSC—Internal Shading System Coefficient.
K_h—Daylighting Factor.
kVA—Kilo-Volts Amperes.
kW—Kilo-Watts.
LPB—Lighting Power Budget.
LPCC—Lighting Power Control Credits.
LS—Listed Space.
NWMA—National Woodwork Manufacturers Association.
o.c.—On Center.
OLA—Occupant Load Adjustment.
OMB—U.S. Office of Management and Budget.
P_b—Base Unit Lighting Power Allowance.
PAF—Power Adjustment Factor.
PF—Projection Factor.
PTAC—Packaged Terminal Air-Conditioner.
R—Thermal Resistance.
r—Thermal Resistivity.
S_{ea}—Shading Horizontal Adjustment Factor.
SC—Shading Coefficient.
SEER—Seasonal Energy Efficiency Ratio.
U_o—Average Thermal Transmittance.
UL—Underwriter's Laboratories, Inc.
ULPA—Unit Lighting Power Allowance.
UPD—Unit Power Density.
VAV—Variable Air Volume.
VCP—Visual Comfort Probability.
VDT—Visual Display Terminal.
VLT—Visible Light Transmittance.
VSEW—Vertical Surface of the Facade.
W.C.—Water Column.
W—Watts.
W/ft ^{2}—Watts Per Square Foot.
W/lin. ft—Watts Per Linear Foot.
W_h—Window Height.
WWR—Window Wall Ratio.
WYEC—Weather Year for Energy Conservation Calculations.

§ 435.100 Explanation of numbering system for standards.

(a) For purposes of this subpart, a derivative of two different numbering systems will be used.

(1) For the purpose of designating a section, the system employed in the Code of Federal Regulations (CFR) will be employed. The number ''435,'' which signifies Part 435, Chapter II of Title 10, Code of Federal Regulations, is used as a prefix for all section headings. The suffix is a two or three digit number beginning with ''.97.'' For example, the lighting section of the standards is numbered § 435.103.

(2) Within each section, a numbering system common to many national voluntary consensus standards is used. This system was chosen because of its

commonality among the buildings industry. A decimal system is used to denote sections and subsections. For example, §9.4.2 refers to section 9, subsection 4, paragraph 2.

(b) The hybrid numbering system is used for two purposes:

(1) The use of the Code of Federal Regulation's numbering system allows the researcher using the CFR easy access to the standards.

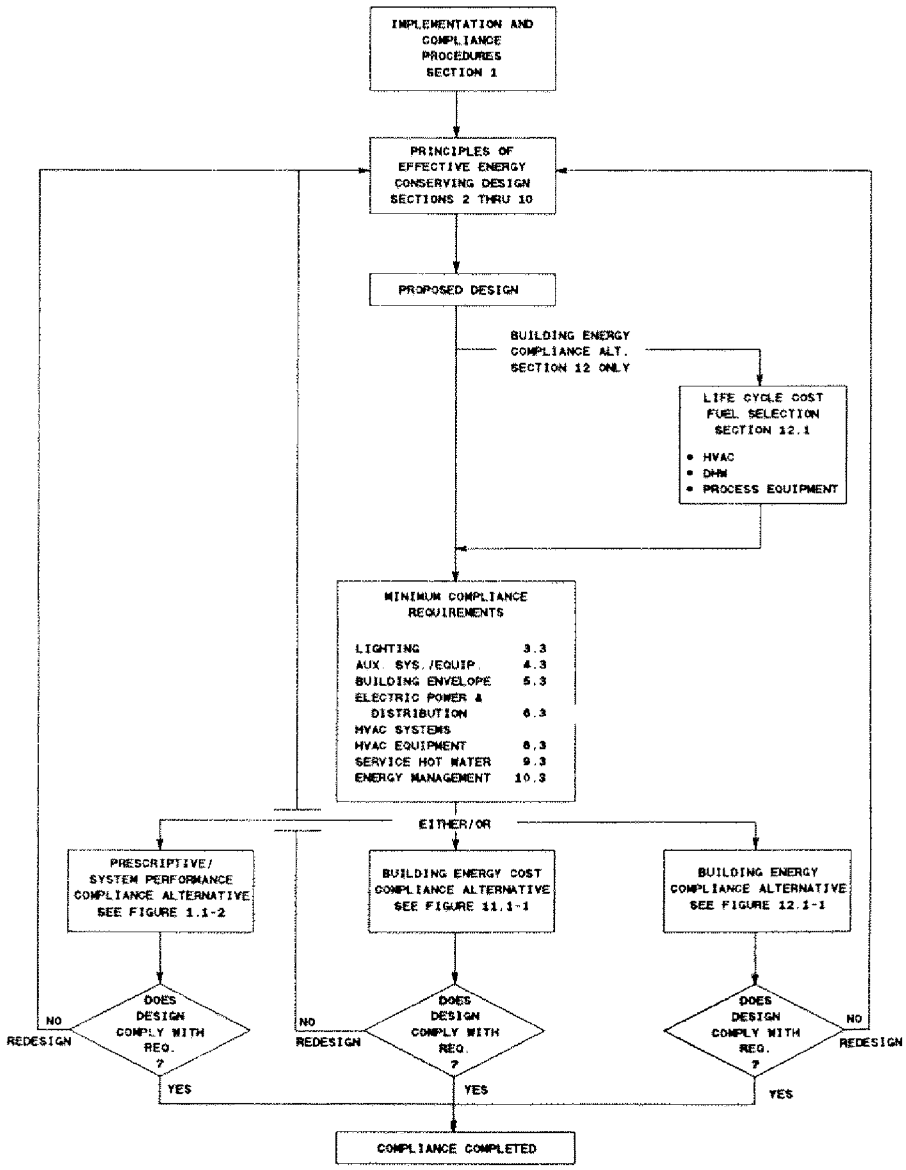
(2) The use of the second system allows the builder, designer, architect or engineer easy access because they are used to the system employed.

(c) To avoid confusion in the use of the two systems, §435.101 through §435.112, the substantive technical sections of the standards, have been numbered so that the last two digits in the suffix designate the section. For example, once the reader enters the body of §435.105: Building Envelope, the number ''5'' is used to designate the section. References throughout the standard do not employ the ''435'' prefix but rather refer to the section by the single or double digit numbers from 1–12.

§435.101 Implementation and compliance procedures for Federal agencies.

Alternative methods of achieving compliance are illustrated in Figure 1.1–1.

Figure 1.1-1 Alternative Methods of Achieving Compliance



1.1 Compliance

1.1.1 The head of each Federal agency responsible for the construction of Federal buildings shall adopt such procedures as may be necessary to assure that the design of the building shall:

1.1.1.1 be undertaken in a manner that provides for appropriate consideration of the Principles of Effective Energy Building Design prescribed in §§ 2.0, 3.2, 4.2, 5.2, 6.2, 7.2, 8.2, 9.2 and 10.2;

1.1.1.2 comply with the minimum requirements of §§ 3.3, 4.3, 5.3, 6.3, 7.3, 8.3, 9.3 and 10.3; and

1.1.1.3 meet or exceed, based upon the analysis of life-cycle cost-effectiveness required by § 1.1.2 below, the following additional requirements:

1.1.1.3.1 the lighting design shall meet either the prescriptive requirements of § 3.4 or the system performance requirements of § 3.5,

1.1.1.3.2 the building envelope design shall meet either the prescriptive requirements of section 5.4 or the system performance requirements of section 5.5, and

1.1.1.3.3 the heating, ventilating and air conditioning systems design shall meet the prescriptive requirements of section 7.4, and

1.1.1.3.4 the service water heating systems design shall meet the prescriptive requirements of section 9.4.

1.1.2 In lieu of meeting the provisions of section 1.1.1 above, the building design shall meet the criteria of the building energy method of section 11.0 or 12.0, Building Energy Compliance Alternatives I and II.

1.1.3 The head of each Federal agency responsible for the construction of Federal buildings shall also assure that the decision-making process for the design of the building shall employ the methodology for estimating and comparing the life-cycle cost of Federal buildings and for determining life-cycle cost-effectiveness prescribed in subpart A of 10 C.F.R. part 436.

1.2 General Approach to Compliance

1.2.1 The standards, in addition to minimum requirements, establish three alternate methods to determine whether the design has achieved compliance.

1.2.2 There are several alternative methods of achieving compliance provided for in the standards:

1.2.2.1 Prescriptive (Sections 3.4, 5.4, 7.4 and 9.4),

1.2.2.2 System Performance (Sections 3.5 and 5.5), or

1.2.2.3 Building Energy (Section 11.0 or 12.0).

1.2.2.4 The criteria established for each of the methods allow for designs that are roughly equivalent in terms of energy conservation. The equivalency of the methods can be demonstrated by designing a building using the Prescriptive approach, then modeling the building using either the System Performance or Building Energy criteria calculation procedures and comparing results.

1.2.3 Compliance with these standards shall be demonstrated by meeting the set of minimum requirements defined in Sections 3.2, 3.3, 4.2, 4.3, 5.2, 5.3, 6.2, 6.3, 7.2, 7.3, 8.2, 8.3, 9.2, 9.3, 10.2, and 10.3 and one of the alternative methods.

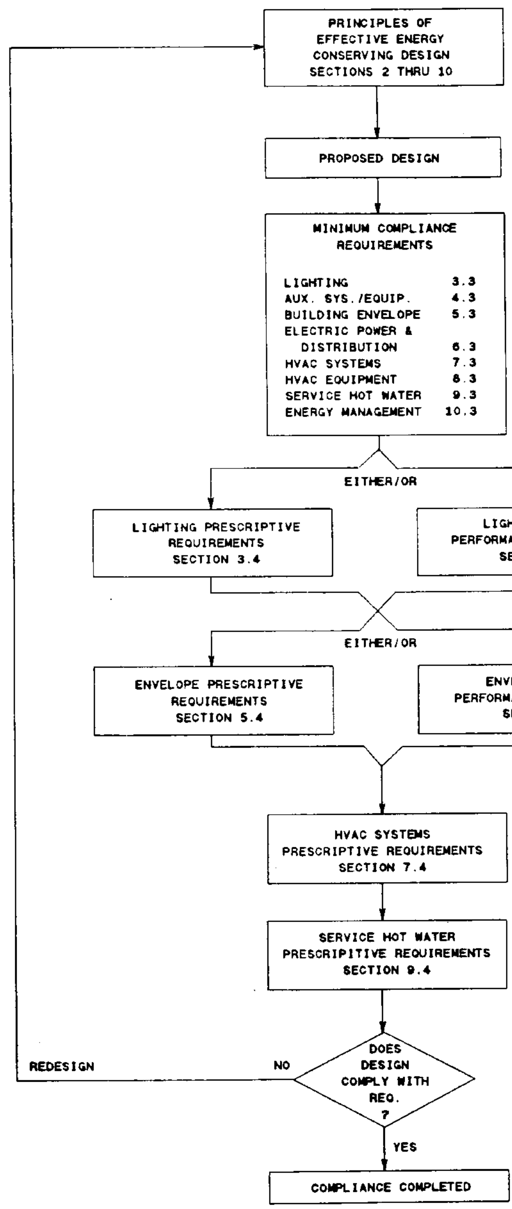
1.3 How To Select a Compliance Method

1.3.1 Use the Prescriptive method when the minimum amount of calculation and effort to achieve compliance is of primary concern. Its requirements can be readily specified in construction documents and are easily reviewed by building code enforcement authorities. The Prescriptive method permits few trade-offs or optimization procedures, but does permit several energy-effective and cost-effective alternate construction options to be used. See Figure 1.1–2.

1.3.2 Use the System Performance method when more innovative design is required, or when the Prescriptive method does not provide the necessary design flexibility. It requires more manual calculations than the Prescriptive method. See Figure 1.1–2

1.3.3 Use either of the Building Energy methods (Sections 11.0 or 12.0) when the most innovative design concepts are being considered. The Building Energy methods allow the trade-off of energy among the building systems as long as the total calculated design annual energy consumption does not exceed the limit prescribed. It will, in general, require the use of a computer program to simulate the operation of the various systems and to model building design energy use in accordance with the building loads and the proposed schedules of operation. See Figures 11–1 and 12–1.

Figure 1.1-2 Prescriptive/System Performance Compliance Alternatives



§435.102 Principles of effective energy building design.

2.1 General

2.1.1 This section complements the other sections of the standards by providing general principles of effective building design. The intention of this section is to provide ideas on how to improve the integration of the building's major energy using subsystems in a cost-effective manner without compromising the building's intended functional use or internal environmental conditions. In addition, more narrowly focused principles are included in sections 3.0 through 10.0.

2.1.2 To comply with the principles of effective design, designers shall use their professional judgment to identify the building's most significant energy requirements and select appropriate solutions from the general strategies found in this section and the more specific strategies found in sections 3.0 through 10.0.

2.2 Identification of Significant Energy Requirements

2.2.1 Before energy design strategies can be developed for a commercial or multi-family high rise residential building, a clear picture of its most significant energy requirements must be developed. The basic approach to achieving an energy conscious design is to improve the energy efficiency of the building by shifting or reducing loads, improving transport systems, and providing efficient environmental systems and controls. This is accomplished by first determining which aspects of the building's energy requirements are the most significant, those that would result in the largest annual energy costs to the building owner if energy conserving strategies were otherwise not applied. For example, for a given building, the largest annual energy cost component may be lighting, followed by cooling, heating, and ventilation, respectively. In this example electricity would be the major energy source. Therefore, peak time-rates of energy use (i.e., peak power demands), as well as direct energy use, would have to be included in any energy analysis. Consideration of peak demands will reduce the requirement for oversizing of energy systems in the building and will also have the added impact of helping to reduce the need for additional, low utilization peak capacity on utility grids.

2.2.2 Once the most significant cost components of the building's energy requirements have been determined, apply the strategies and design solutions listed below and those that appear in each of the following sections of the standards. ln the example noted above, lighting solutions would be addressed first, followed by cooling, heating, and then ventilation.

2.2.3 Research results indicate that the most significant energy uses for any given commercial or multi-family high rise residential building are generally not accurately identifiable by professional intuition. Therefore, use shall be made of one of the several available analysis tools, some of which are microcomputer-based.

2.3 General Solution Strategies

2.3.1 Consider energy efficiency from the initiation of the building design process, since design improvements are most easily and effectively made at that time. Seek the active participation of members of the design team early in the design process, including the owner, architect, engineer, and builder, if possible. Consider building attributes such as building function, form, orientation, window/wall ratio, and HVAC system types early in the design process. Each has major energy implications. These considerations most likely will result in solutions that minimize both construction and operation costs, including energy demand charges.

2.3.2 Address the building's energy requirements in the following sequence: minimize impact of the building functional requirements; minimize loads; improve the efficiency of distribution and conversion systems; and integrate building subsystems into an efficient whole. Each of these is discussed below.

2.3.2.1 Minimize impact of functional requirements by identifying major areas that offer energy efficiency opportunities based on the building's functional use, human occupancy requirements, and site characteristics. These areas will vary considerably from building to building depending upon function and service requirements, and shall be considered when applying the criteria of these standards.

2.3.2.2 Minimize loads by analyzing the external and internal loads to be imposed on building energy-using subsystems, both for peak-load and part-load conditions. Include a determination of how the building relates to its external environment in the analysis, either adaptively or defensively. Consider changes in building form, aspect ratio, and other attributes that reduce, redistribute, or delay (shift) loads.

2.3.2.3 Improve subsystems by analyzing the diversified energy and demand (power) requirements of each energy-using subsystem serving the functional requirements of the building. Consider static and dynamic efficiency of energy conversion and energy transport subsystems and include consideration of opportunities to reclaim, redistribute and store energy for later use.

2.3.2.4 Alternative ways to integrate systems into the building will be accomplished by considering both power and time components of energy use. Identify, evaluate, and design each of these components to control the overall design energy consumption. The following shall be considered when integrating major building subsystems:

2.3.2.4.1 Address more than one problem when developing design solutions, and make maximum use of building components already present for non-energy reasons (e.g., windows, structural mass);

2.3.2.4.2 Examine design solutions that consider time since sufficient energy may already be present from the environment (e.g., solar heat, night cooling) or from internal equipment (e.g., lights, computers) but available at different times than needed. Thus, active (heat pumps with water tanks) and passive (building mass) storage techniques may be considered;

2.3.2.4.3 Examine design solutions that consider anticipated space utilization. For example, in large but relatively unoccupied spaces, task or zone heating may be considered. Transporting energy (light and heat) from locations of production and availability to locations of need shall be considered instead of the purchase of additional energy;

2.3.2.4.4 Never reject waste energy at temperatures usable for space conditioning or other practical purposes, without calculating the economic benefit of energy recovery;

2.3.2.4.5 Consider design solutions that provide more comfortable surface temperatures or increase availability of controlled daylight in buildings in which human occupancy is a primary function;

2.3.2.4.6 Use design solutions that are easily understood as they have a greater probability of use by building occupants; and

2.3.2.4.7 Where the functional requirements of the building may change, the installed environmental system should be designed to be adaptable to meet functional changes that can be anticipated as well as providing flexibility to meet indeterminate future changes in use, occupancy or other functions.

§ 435.103 Lighting.

3.1 General

3.1.1 This section contains principles of design, a set of minimum requirements, and two alternative compliance procedures, prescriptive and systems performance, for the design of building lighting and lighting control systems, and includes provisions for daylighting credit. The procedures in this section are solely for use in establishing lighting design budgets and are not intended for use as lighting design procedures.

3.1.2 *Scope.* The following are covered by this section:

3.1.2.1 Interior spaces of buildings;

3.1.2.2 Building exteriors and exterior areas, such as entrances, exits, and loading docks; and

3.1.2.3 Roads, grounds, parking, and other exterior areas where lighting is energized through the building electrical service.

3.1.3 *Exemptions.* The following are exempt from these standards:

3.1.3.1 Outdoor manufacturing, commercial greenhouses, and processing facilities;

3.1.3.2 Lighting power for theatrical production studios and stages, television broadcasting studios, audio-visual presentation, and entertainment facilities in spaces such as stages, hotel ballrooms, nightclubs, discos, and casinos, and where lighting is an essential technical element for the function performed;

3.1.3.3 Specialized luminaires for medical and dental purposes;

3.1.3.4 Outdoor athletic facilities;

3.1.3.5 Lighting power for display lighting required for art exhibits or displays in galleries, museums and monuments;

3.1.3.6 Exterior lighting for public monuments;

3.1.3.7 Special lighting needs for research;

3.1.3.8 Lighting power for lighting used solely for indoor plant growth during the hours of 10:00 p.m. to 6:00 a.m.;

3.1.3.9 Emergency lighting that is automatically ''off'' during normal operation;

3.1.3.10 High risk security areas or any area identified by local ordinances or regulations or by security or safety personnel as requiring additional lighting;

3.1.3.11 Lighting power densities for spaces with enhanced lighting specifically designed for primary use by the visually impaired, hard of hearing, or for senior citizens;

3.1.3.12 Lighting for signs;

3.1.3.13 Store-front exterior-enclosed display windows in retail facilities; and

3.1.3.14 Lighting for dwelling units.

3.1.4 *Building Lighting Power Allowance*. The lighting power allowance for a building consists of the Exterior Lighting Power Allowance (ELPA), in accordance with section 3.3, plus the Interior Lighting Power Allowance (ILPA) in accordance with section 3.4 or 3.5. This lighting power allowance is the upper limit to which the building can be designed, based on the criteria of the compliance alternative chosen.

3.1.4.1 The prescriptive criteria in section 3.4 provides a single compliance procedure based on calculating a lighting budget by building type or major area type within which a designer can flexibly design a lighting solution. To obtain credit for specific lighting energy conservation measures, use section 3.5, section 11.0, or section 12.0.

3.1.4.2 The systems performance criteria in section 3.5 provides a more complex compliance procedure based on calculating a lighting budget by activity or spaces within which the designer can flexibly design a lighting solution and receive credit for energy conserving controls and daylighting measures. To receive credit for more complex lighting conservation measures use section 11.0 or 12.0.

3.1.5 *Credit for Daylighting*. Daylighting credit, for reduced use of electric lighting energy resulting from the use of automatic lighting control devices in conjunction with fenestration (e.g., windows and skylights), may be taken if the systems performance alternative in section 3.5 is chosen. However, if such daylighting credit is to be applied to other building subsystems, such as use of additional fenestration area, section 11.0 or 12.0 must be used. Thermal credit provisions for daylighting are found in Section 5.0.

3.1.6 *Compliance*. A building shall be considered in compliance with this section if the following conditions are met:

3.1.6.1 The minimum requirements of section 3.3 are met;

3.1.6.2 The exterior lighting power to be installed is not greater than the Exterior Lighting Power Allowance (ELPA), calculated using Equation 3.3–1;

3.1.6.3 The interior lighting power to be installed is not greater than the Interior Lighting Power Allowance (ILPA), based on either the Prescriptive Criteria in section 3.4 or the Systems Performance Criteria in section 3.5.

3.1.6.4 Tradeoffs between ILPA and ELPA are not allowed. Tradeoffs of the interior Lighting Power Budgets (LPB) among interior spaces are allowed as long as the total Connected Lighting Power (CLP) within the building does not exceed the Interior Lighting Power Allowance (ILPA) and Lighting Power Control Credits (LPCC) are used only for connected lighting power in those spaces for which credit is claimed.

Tradeoffs of exterior lighting power budgets among exterior areas are allowed as long as the total Connected Lighting Power (CLP) of exterior lighting does not exceed the Exterior Lighting Power Allowance (ELPA) and the allowance for the building exterior surfaces is not exceeded.

3.1.7 *Multi-Building Facilities.* The total lighting power allowances for each building in a multi-building facility shall be calculated separately.

3.2 Principles of Design

3.2.1 The lighting system is designed to provide a productive, safe, and pleasing visual environment for the intended use of the space. However, lighting is both a major energy end use in commercial buildings (especially in office buildings) and a major contributor to internal loads by increasing cooling loads and decreasing heating loads. Therefore, it is important to produce a design that meets the lighting functional criteria of the space as well as one that minimizes energy use. Recommended maintained illuminance levels for visual tasks and surrounding lighted areas are included in the *IES Lighting Handbook, Applications (1983) or Reference (1985).* Principles of energy conserving design within that context are described below.

3.2.2 The following Design Concepts shall be considered in the design of lighting that is both energy efficient and visually effective.

3.2.2.1 Energy use is determined by the lighting load (demand power) and its duration of use (time). Minimize the actual demand load rather than just the apparent connected load, and control the load rather than just switching, if switching may adversely affect the quality of the luminous environment.

3.2.2.2 Consider daylighting along with the proper use of controls so that the savings from electric lighting can be realized. Design should be sensitive to window glare, sudden changes in luminances, and general use acceptance of controls. Window treatment (blinds, drapes and shades) and glazing should be carefully selected to control direct solar penetration and luminance extremes while still maintaining view and daylight penetration.

3.2.2.3 Design lighting systems so that illumination required for tasks is primarily limited to the location of the task and from a direction that will minimize direct glare and veiling reflections on the task. For example, the ideal positioning of work stations is between the rows of ceiling-mounted luminaires with the direction of view parallel to the primary task. In densely-occupied work spaces, uniform distribution of general lighting may be most appropriate. Where supplementary task illumination is necessary, general or ambient illumination should not be lower than a third of the luminance required for the task. This will help maintain luminance rates that are visually comfortable.

3.2.2.4 Use task lighting, whenever possible, to accommodate the need for higher lighting levels due to task visual difficulty, glare, intermittently changing requirements, or individual visual differences (poor and aging eyesight).

3.2.2.5 Group similar activities so high illuminance or special lighting for particular tasks are localized in certain rooms or areas, and so that less efficient fixtures required for critical glare control do not have to be installed uniformly when they are only required sparsely.

3.2.2.6 When indirect lighting is appropriate, use schemes that create reasonably uniform ceiling luminances. If this is achieved, work spaces may be located anywhere and occupants may face in any direction without being subject to excessive veiling reflection on the tasks. The indirect system may allow more effective use of the space than other types of lighting systems. However, indirect lighting systems generally have lower utilization factors, and may require increased ceiling height to provide uniform ceiling luminance.

3.2.2.7 Use lighting controls throughout that maintain proper lighting levels when and where it is needed but also allow reductions in lighting when tasks are less critical, or spaces are not fully occupied. The designer must consider user acceptance of control strategies to maximize energy efficiency.

3.2.2.8 Use lower levels of ambient lighting in situations such as merchandising, where the contrast between accent lighting and ambient lighting is critical. Accent lighting shall not exceed five (5) times the ambient level. Consider fewer, more effectively-accented displays, rather than more ineffectively-accented ones.

3.2.3 The following guidelines identify Fixture and Lamp selection strategies to be considered in the selection of luminaires and lamps for inclusion in an energy efficient, visually-effective design:

3.2.3.1 Consider the use of more efficient equipment with appropriate distribution, glare control and visual characteristics. Utilize fixture designs that will provide high lighting efficiency while meeting the other lighting objectives of the installation.

3.2.3.2 Review visual comfort probability (VCP) data, available from manufacturers, for specific luminaires when minimizing discomfort glare is a criterion.

3.2.3.3 Consider luminaire construction that minimizes light loss due to dirt collection.

3.2.3.4 Investigate the use of dimmers to reduce energy consumption when the system is new and capable of providing more light than the average depreciated design value.

3.2.3.5 Use more efficient lamps with appropriate luminous efficacy, life expectancy and spectrum distribution and color rendering characteristics.

3.2.3.6 Use more efficient ballasts for fluorescent and HID lamps with appropriate ballast factors, power factor, noise rating, starting and restarting characteristics.

3.2.3.7 Use luminaires with heat removal and heat recovery capabilities, thereby allowing the lighting equipment to operate more efficiently at a lower ambient temperature.

3.2.3.8 Limit the use of lower efficiency lamps, such as incandescent, to only those applications where their color, lumens or distribution characteristics cannot be duplicated by other sources. Due to their lower efficiency, the use of ''extended service'' incandescent lamps should be limited to those applications where fixtures are difficult to reach and/or maintenance costs for revamping will be excessive.

3.2.4 Space Design

3.2.4.1 It is important to carry through on the lighting design when completing the interior design. Reduce light absorption by encouraging the use of lighter finishes, particularly on ceilings, walls and partitions. Select colors and surface materials so that their reflectance values are within the ranges recommended by the IES. This will aid the efficient use of light and help to provide comfortable luminance ratios.

3.2.4.2 In offices with visual display terminals (VDT) that are susceptible to reflections, it may be necessary to use reflectances for some room surfaces at the low end of the recommended ranges to reduce unwanted reflections on the screens. Where practical, treat the screens of VDTs with anti-glare materials to avoid veiling reflection.

3.3 Minimum Requirements

3.3.1 Lighting Controls.

3.3.1.1 All lighting shall be provided with manual, automatic, or programmable controls.

3.3.1.1.1 *Exception to Section 3.3.1.1:*

(a) controls for emergency or exit lighting.

3.3.1.2 *Minimum Number of Lighting Controls.* Each space enclosed by walls or ceiling-height partitions shall be provided with control(s) that, together or alone are capable of controlling all lights within that space, excluding those requiring continuous operation for security purposes.

3.3.1.2.1 The minimum number of controls shall not be less than:

(a) One lighting control for each space; and

(b) One lighting control for each task or group of task locations within an area of 450 ft^2 or less.

3.3.1.2.2 *Equivalent Number of Controls.* The minimum number of controls may be reduced, by using an equivalent number of controls from Table 3.3–1, where control types listed in Table 3.3–1 are used. However, the minimum number of controls may not be reduced to less than one control for each 1500 W of connected lighting power.

Table 3.3-1
Equivalent Number of Controls

TYPE OF CONTROL	EQUIVALENT NUMBER OF CONTROLS
Manually operated on-off switch	1
Occupancy sensor	2
Timer-Programmable from the space being controlled	2
Three level, including off, step control or pre-set dimming	2
Four level, including off, step control or pre-set dimming	3
Automatic or continuous dimming	3

3.3.1.2.3 *Exceptions to Section 3.3.1.2:*

(a) Lighting control requirements for spaces that must be used as a whole, such as public lobbies of office buildings, hotels, and hospitals; retail and department stores and warehouses, storerooms, and service corridors under centralized supervision, shall be controlled by a lesser number of controls, but not less than one control for each 1500 W of connected lighting power, or a total of three (3) controls, whichever is greater. Lighting in such spaces shall be controlled in accordance with the work activities.

(b) Hotel and motel guest rooms shall have one or more master controls at the main entry door that turn off all permanently wired lighting fixtures and lighting and television receptacles. For multiple room suites, controls at the entry of each room, in lieu of a master switch, will meet these requirements.

3.3.1.3 Controls provided for task areas, if readily accessible, may be mounted as part of the task lighting luminaire.

3.3.1.4 Control of the same load from more than one location shall not be credited as additional control points.

3.3.1.5 All lighting controls shall be readily accessible to personnel occupying or using the space. Exceptions are automatic controls, programmable controls, lighting for safety hazards and security, controls requiring trained operators, and those controls for spaces that must be used as a whole.

3.3.1.6 Exterior lighting shall be automatically controlled by timer, photocell, or combination of timer and photocell. Timers shall be of the automatic type or otherwise capable of adjustment for seven days and for seasonal daylight schedule variations. All time-controllers shall be equipped with back-up mechanisms to keep time during a four hour power outage.

3.3.1.7 When the building is served by an energy management system, programmable controls, shared tenant services that affect interior environments, or ''intelligent building'' systems, provisions shall be made to incorporate lighting controls into the system if a separate automatically-controlled lighting system is not provided.

3.3.2 Fluorescent Lamp Ballasts.

3.3.2.1 Fluorescent lamp ballasts shall have a ballast efficacy factor not less than that shown in Table 3.3–2.

3.3.2.1.1 *Exception to 3.3.2.1:* Ballasts not included in Table 3.3–2 and ballasts designed for use with dimming controls are excluded from these criteria.

Table 3.3-2
Fluorescent Ballast For Efficacy Factors*

NUMBER OF LAMPS	LAMP TYPE	NOMINAL OPERATIONAL INPUT VOLTAGE	DESIGN STARTING TEMPERATURE	INPUT FREQUENCY	MAX. LAMP OPERATING TEMPERATURE	MIN. BALLAST EFFICIENCY FACTOR
1	4 ft rapid start	120 or 277	>40 °F	60Hz	<1000 m amp	1.805
2	4 ft rapid start	120	>40 oF	60Hz	<1000 m amp	1.060
2	4 ft rapid start	277	>40 °F	60Hz	<1000 m amp	1.050
2	8 ft slimline	120 - 277	>40 °F	60Hz	<1000 m amp	0.570
2	8 ft high output, rapid start	120 - 277	<40 °F	60Hz	<1000 m amp	0.390

* For ballasts not specifically designed for use with dimming controls.

3.3.2.2 The Ballast Efficacy Factor shall be calculated in accordance with Equation 3.3–1:

$$BEF = \frac{BF}{\text{Power Input}}$$

Equation 3.3–1

Where:

BEF=Ballast Efficacy Factor.

BF=Ballast Factor, expressed as a percent.

Power Input=Total Wattage of combined lamps and ballasts

3.3.2.2.1 Tests for ballast factor and power input shall be in accordance with *ANSI Standard C–82.2–1984* ''Method of Measurement for Fluorescent Lamp Ballasts'', using ''Standard'' F40T1240A, F96T12 75 watt, or F96T12H0 110 watt lamps.

3.3.2.3 One-lamp or three-lamp fluorescent luminaires shall be tandem-wired to eliminate unnecessary use of single lamp ballasts if they are: used for general lighting; recess mounted within ten feet center-to-center of each other; or pendant or surface mounted within 1 ft of each other, and within the same room. Tandem wiring consists of pairs of luminaires operating with one lamp in a luminaire powered from a single two-lamp ballast contained in a second luminaire.

3.3.2.3.1 *Exception to Section 3.3.2.3:*

(a) Three-lamp ballasts may be used.

3.3.2.4 Fluorescent lamp ballasts shall have a power factor equal to or greater than 80%.

3.3.2.4.1 *Exception to 3.3.2.4:* Ballasts for circline and compact fluorescent lamps and low wattage, high intensity discharge lamps of less than 100 watts.

3.4 Lighting—Prescriptive Compliance Alternative

3.4.1 Purpose

3.4.1.1 This subsection provides a prescriptive procedure for determining an exterior lighting power allowance and the Interior Lighting Power Allowances for illumination systems installed in six types of new buildings. It is intended for use with buildings having simple lighting requirements and where the minimum amount of calculation and effort to achieve compliance is of primary concern. For other building types, to receive credit for switching, daylighting, or other trade-offs, or to receive credit for lighting optimization, use section 3.5, section 11.0, or section 12.0.

3.4.1.2 This section also serves as the basis for calculating the skylight area in section 5.3.9.6, and may be used for estimating the lighting heat gain for calculating the internal load density in Equation 5.4–1 and section 5.5.6.2.

3.4.2 General

3.4.2.1 This method for compliance prescribes a total allowable Unit Lighting Power Allowance (ULPA) for interior lighting for the building type/area as listed in Table 3.4–1. There is no recognition of specific makeup of spaces and activities within the building.

Table 3.4-1
Prescriptive Unit Lighting Power Allowance (ULPA), W/ft^2

BUILDING TYPE/AREA FUNCTION	Gross Lighted Area Ranges: 0 to 2,000 ft^2	2,001 to 10,000 ft^2	10,001 to 25,000 ft^2	25,001 to 50,000 ft^2	50,001 to 250,000 ft^2	> 250,000 ft^2	Effective Date
Food Service							
Fast Food/Cafeteria	1.50	1.38	1.34	1.32	1.31	1.30	1988
	0.92	0.85	0.82	0.81	0.81	0.80	1993
Leisure Dining/Bar	2.20	1.91	1.71	1.56	1.46	1.40	1988
	1.60	1.56	1.52	1.48	1.44	1.40	1993
Offices	1.90	1.81	1.72	1.65	1.57	1.50	1988
	1.40	1.34	1.27	1.22	1.16	1.11	1993
Retail[1]							
Retail General	3.30	3.08	2.83	2.50	2.28	2.10	1988
	2.70	2.52	2.32	2.05	1.87	1.72	1993
Mall Concourse Multi-Store Service	1.60	1.58	1.52	1.46	1.43	1.40	1988
	0.69	0.68	0.65	0.63	0.61	0.60	1993
Service Establishment	2.70	2.37	2.08	1.92	1.80	1.70	1988
	2.81	2.03	1.78	1.65	1.54	1.46	1993
Garages	0.30	0.28	0.24	0.22	0.21	0.20	1988
	0.25	0.24	0.23	0.22	0.21	0.20	1993
Schools							
Pre-elementary	1.80	1.80	1.72	1.65	1.57	1.50	1988
	1.33	1.33	1.27	1.22	1.16	1.11	1993
Jr. High/High School	1.90	1.90	1.88	1.83	1.76	1.70	1988
	1.40	1.40	1.39	1.35	1.30	1.26	1993
Technical/Vocational	2.40	2.33	2.17	2.01	1.84	1.70	1988
	1.77	1.72	1.60	1.49	1.36	1.26	1993
Warehouse/Storage	0.80	0.66	0.56	0.48	0.43	0.40	1988
	0.60	0.50	0.42	0.36	0.32	0.30	1993

Notes:
1. Includes general, merchandising and display lighting.

3.4.3 Exterior Lighting Power Allowance

3.4.3.1 Building exteriors and exterior areas, as defined in section 3.1.2.2, and roads, grounds, parking, and other exterior areas, defined in section 3.1.2.3, shall have a lighting power density not to exceed the Exterior Lighting Power Allowance (ELPA), which is the sum of the allowances for each of the areas listed above, as calculated by Equation 3.4–1 using unit power densities from Table 3.4–2.

Table 3.4-2
Exterior Lighting Unit Power Density

AREA DESCRIPTION	UNIT POWER DENSITY (UPD)
Exit (with or without canopy) . . .	25 W/lin. ft of door opening
Entrance (without canopy)	30 W/lin. ft of door opening
Entrance (with canopy)	
High Traffic (retail, hotel, airport, theater, etc.)	10 W/ft^2 of canopied area
Light Traffic (hospital, office, school, etc.)	4 W/ft^2 canopied area
Loading area	0.40 W/ft^2
Loading door	20 W/lin. ft of door opening
Building Exterior Surfaces/Facades	0.25 W/ft^2 of surface area to be illuminated
Storage and non-manufacturing work areas	0.20 W/ft^2
Other activity areas for casual use such as picnic grounds, gardens, parks, and other landscaped areas	0.10 W/ft^2
Private driveways/walkways	0.10 W/ft^2
Public driveways/walkways	0.15 W/ft^2
Private parking lots	0.12 W/ft^2
Public parking lots	0.18 W/ft^2

$$ELPA=\Sigma\ DO_i\ UPD_{Di}+\Sigma\ A_i\ UPD_{Ai}=\Sigma\ [(DO_1\times UPD_{D1}\ ...\ +DO_n\times UPD_{Dn})+(A\times UPD_{A1}\ ...\ A_n\times UPD_{An})]$$ *Equation 3.4–1*

Where:

ELPA=Exterior lighting power allowance, in Watts.

i=numerical subscript (1,2, ... n) for each occurrence of exterior openings or exterior areas of the building.
n=total number of occurrences of exterior openings or areas of the building.
DO=Door opening, linear feet.
UPD_D=Unit power density for the door, W/lin. ft, from Table 3.4–2.
UPD_A=Unit power density for the area in W/ft^2, from Table 3.4–2.
A=Exterior area in ft^2.

3.4.4 Interior Lighting Power Allowance

3.4.4.1 The Interior Lighting Power Allowance (ILPA) shall be calculated using the prescriptive Unit Lighting Power Allowances (ULPA) in Table 3.4–1. First, determine if the predominant function of the proposed building is one of the six building types listed in Table 3.4–1. If not, section 3.5, 11.0, or 12.0 must be used. Next, determine whether the proposed design has secondary functions that are 10% or more of the gross lighted area of the building and are listed in Table 3.4–1. If so, the designer has the option of using the predominant building function to calculate the ILPA or using the calculation method for multiple-use buildings in section 3.4.4.1.2 below.

3.4.4.1.1 If the proposed building has only one function, has no secondary functions with 10% or more of the gross lighted area, or the designer chooses to determine the ILPA based on only one function, Equation 3.4–2 shall be used to determine the building ILPA. First, select the appropriate building type in Table 3.4–1, and the appropriate column for the Gross Lighted Area (GLA) of the proposed building. This value is the Unit Lighting Power Allowance (ULPA). Determine the ILPA by multiplying the ULPA by the GLA as shown in Equation 3.4–2.

$$ILPA=ULPA\times GLA$$

Equation 3.4–2

Where:
ILPA=Interior Lighting Power Allowance, in Watts.
ULPA=Unit Lighting Power Allowance, in W/ft^2,from Table 3.4–1.
GLA=Gross Lighted Area of the Proposed Building, in ft^2.

3.4.4.1.2 If a building design has more than one function listed in Table 3.4–1, such as an office building with parking and retail stores, with more than 10% of the gross lighted area, Equation 3.4–3 may be used to calculate the building Interior Lighting Power Allowance (ILPA). First, determine the gross lighted area of the building (GLA) and the gross lighted area for each qualifying secondary function (GLA_f) in the building. Select the ULPA from Table 3.4–1 under the column corresponding to the gross lighted area of the entire proposed building and multiply it by the gross lighted area of that function. Sum the products to determine the building ILPA, as shown in Equation 3.4–3 below.

$$ILPA=ULPA_p\ GLA_p+\Sigma(ULPA_i\ GLA_i)=[ULPA_p\ GLA_p+(ULPA_{f1}\ GLA_{f1}+ULPA_{f2}\ GLA_{f2}\ .\ .\ .\ ULPA_{fn}\ GLA_f)]$$

Equation 3.4–3

Where:
i=numerical subscript (1,2, . . . n) for each secondary function with 10% or more of the gross lighted area of the building.
n=number of secondary functions.
ILPA=Interior Lighting Power Allowance, in Watts.
$ULPA_p$=Unit Lighting Power Allowance of the predominant function based on the gross lighted area of the entire building, from Table 3.4–1, in W/ft^2.
$ULPA_f$=Unit Lighting Power Allowance of qualifying secondary functions based on the gross lighted area of the entire building, from Table 3.4–1, in W/ft^2.
GLA_p=Gross lighted area of the predominant function of the proposed building.
GLA_f=Gross lighted area of each qualifying secondary function.

3.4.4.3 *Lighting compliance in partially defined speculative buildings.* For defined functions in partially defined speculative buildings, the total connected lighting power shall not exceed the interior lighting power allowance for that portion of the building. When determining the ILPA for those cases, the gross lighted area of the entire building must be used.

3.5 Lighting—System Performance Compliance Alternative

3.5.1 Purpose

3.5.1.1 This subsection provides a procedure for determining the maximum lighting power allowance for buildings, roads and grounds. It allows the designer to take credit for the use of daylighting and other lighting controls. It also serves as a basis for estimating the lighting heat gain and lighting energy use for Section 5.0.

3.5.2 General

3.5.2.1 The total Connected Lighting Power (CLP) in a building, including permanently installed lighting plus supplemental or task related lighting provided by movable fixtures or plug-in luminaires, shall not exceed the Interior Lighting Power Allowance (ILPA). A Lighting Power Control Credit (LPCC), taken for individual spaces, may only be utilized for credit to connected lighting power in those spaces for which credit is claimed.

3.5.2.2 *Compliance for lighting in partially defined speculative buildings.* The total connected lighting power of lighting designs of defined areas of partially defined speculative buildings shall not exceed the interior lighting power allowance for those areas of the building for which lighting has been designed.

3.5.3 The Lighting Power Budget (LPB) of each interior space shall be determined in accordance with Equation 3.5–1.

$$LPB=(A\times UPD_b\times AF)+LPCC$$

Equation 3.5–1

Where:

LPB=Lighting power budget of the space, in watts

A_r=Area of the room at the horizontal lighted working place, ft^2

UPD_b=Base Unit Power Density, W/ft^2, (Table 3.5–1)

AF=Area factor of the room, (Figure 3.5–1)

$LPCC$=Lighting Power Control Credit, as determined by §3.5.6

3.5.3.1 The room area (A) shall be calculated from the inside dimensions of the room.

3.5.3.2 The Base Unit Power Density (UPD) shall be selected from Table 3.5–1. For applications to areas or activities other than those given, select values for similar areas or activities.

TABLE 3.5-1
BASE UPD (P_b) FOR AREA/ACTIVITY

AREA/ACTIVITY COMMON ACTIVITY AREAS	1989 UPD	1989 NOTE	1993 UPD	1993 NOTE
Auditorium	1.6	(d)	1.4	(d)
Corridor	0.8	(a)	0.8	(a)
Classroom/Lecture Hall	2.0		1.0	
Elec/Mech Equipment Room				
General	0.7	(a)	0.7	(a)
Control Rooms	1.5	(a)	1.5	(a)
Food Service				
Fast Food/Cafeteria	1.3		0.8	
Leisure Dining	2.5	(c)	1.4	(c)
Bar/Lounge	2.5	(c)	1.3	(c)
Kitchen	1.4		1.4	
Recreation/Lounge	0.7		0.5	
Stairs				
Active Traffic	0.6		0.6	
Emergency Exit	0.4		0.4	
Toilet & Washroom	0.8		0.5	
Garage				
Auto/Pedestrian Circulation	0.3		0.25	
Parking Area	0.2		0.2	
Laboratory	2.3		2.2	
Library				
Audio Visual	1.1		1.1	
Stack Area	1.5		1.5	
Card File & Cataloging	1.6		0.8	
Reading Area	1.9		1.0	
Lobby (General)				
Reception & Waiting	1.0		0.55	
Elevator Lobbies	0.8		0.4	
Atrium (Multi-Story)				
First 3 Floors	0.7		0.4	
Each Additional Floor	0.2		0.15	
Locker Room & Shower	0.8		0.6	

AREA/ACTIVITY COMMON ACTIVITY AREAS	1989 UPD	1989 NOTE	1993 UPD	1993 NOTE
Offices				
Enclosed offices of less than 900 ft² and all open plan offices w/out partitions or w/partitions lower than 4.5 ft below ceiling.		(h)		(h)
Reading, Typing and Filing	1.8	(g)	1.3	(g)
Drafting	2.6	(g)	2.2	(g)
Accounting	2.1	(g)	1.8	(g)
Open plan offices, 900 ft² or larger, w/medium height partitions 3.5 to 4.5 ft below ceiling.		(h)		(h)
Reading, Typing and Filing	1.9	(a)	1.5	(a)
Drafting	2.9	(a)	2.6	(a)
Accounting	2.4	(a)	2.1	(a)
Open plan offices, 900 ft² or larger, w/partitions higher higher than 3.5 ft below ceiling.		(h)		(h)
Reading, Typing and Filing	2.2	(a)	1.7	(a)
Drafting	3.4	(a)	3.0	(a)
Accounting	2.7	(a)	2.4	(a)
Common Activity Areas				
Conference/Meeting Room	1.8	(d)	1.3	(d)
Computer/Office Equipment	2.1		2.1	
Filing, Inactive	1.0		1.0	
Mail Room	1.8		1.8	
Shop (Non-Industrial)				
Machinery	2.5		2.5	
Electrical/Electronic	2.5		2.5	
Painting	1.6		1.6	
Carpentry	2.3		2.3	
Welding	1.2		1.2	
Storage & Warehouse				
Inactive Storage	0.3		0.2	
Active Storage, Bulky	0.3		0.3	
Active Storage, Fine	1.0		0.9	
Material Handling	1.0		1.0	
Unlisted Space	0.2		0.2	

TABLE 3.5-1 (Continued)
BASE UPD (P_b) FOR AREA/ACTIVITY

AREA/ACTIVITY SPECIFIC BUILDINGS	1989 UPD	1989 NOTE	1993 UPD	1993 NOTE
Airport, Bus and Rail Station				
Baggage Area	0.8		0.75	
Concourse/Main Thruway	0.9		0.45	
Ticket Counter	2.5		1.3	
Waiting & Lounge Area	1.2		0.6	
Bank				
Customer Area	1.0		0.8	
Banking Activity Area	2.8		2.2	
Barber & Beauty Parlor	2.0		1.6	
Church, Synagogue, Chapel				
Worship/Congregational	2.3		1.3	
Preaching & Sermon/Choir	2.7		1.8	
Dormitory				
Bedroom	1.0		0.6	
Bedroom with Study	1.3		1.3	
Study Hall	1.8		0.9	
Fire & Police Department				
Fire Engine Room	0.7		0.7	
Jail Cell	0.8		0.4	
Hospital/Nursing Home				
Corridor	1.3	(a)	0.9	(a)
Dental Suite/Exam/Treat	1.6		1.4	
Emergency	2.3		2.0	
Laboratory	1.9		1.7	
Lounge/Waiting Room	0.9		0.6	
Medical Supplies	2.4		2.4	
Nursery	2.0		1.6	
Nurse Station	2.1		1.8	
Occu./Physical Therapy	1.6		1.4	
Patient Room	1.4		0.9	
Pharmacy	1.7		1.5	
Radiology	2.1		1.8	
Surgical & O.B. Suites				
General Area	2.1		1.8	
Operating Room	7.0		6.0	
Recovery	3.0		2.0	
Hotel/Conference Center				
Banquet Room/Multipurpose	2.4	(d)	1.4	(d)
Bathroom/Powder Room	1.2		0.6	
Guest Room	1.4		0.7	
Public Area	1.1		0.8	
Exhibition Hall	2.6		1.3	
Conference/Meeting	1.8	(d)	1.5	(d)
Lobby	1.9		1.3	
Reception Desk	2.4		2.4	
Laundry				
Washing	0.9		0.6	
Ironing & Sorting	1.3		1.3	
Museum & Gallery				
General Exhibition	1.9		1.2	
Inspection/Restoration	3.9		3.0	
Storage (Artifacts)				
Inactive	0.6		0.25	
Active	0.7		0.5	
Post Office				
Lobby	1.1		0.8	
Sorting & Mailing	2.1		2.1	
Service Station/Auto Repair	1.0		0.8	
Theater				
Performance Arts	1.5		1.1	
Motion Picture	1.0		0.75	
Lobby	1.5		1.0	
Retail Establishments (Merchandising & Circulation Area) Applicable to all lighting, including accent and display lighting, installed in merchandising and circulation areas				
Type A	5.6	(e)	6.0	(e)
Type B	3.2	(e)	2.9	(e)
Type C	3.3	(e)	2.7	(e)
Type D	3.0	(e)	2.5	(e)
Type E	2.8	(e)	2.4	(e)
Type F	2.7	(e)	2.6	(e)
Mall Concourse	1.4		0.6	
Retail Support Area				
Tailoring	2.1		2.1	
Dressing/Fitting Rooms	1.4		1.1	

TABLE 3.5-1 (Continued)
BASE UPD (P_b) FOR AREA/ACTIVITY

AREA/ACTIVITY INDOOR ATHLETIC AREAS	1989 UPD	1989 NOTE (b)	1993 UPD	1993 NOTE (b)
Seating Area, All Sports	0.4		0.4	
Badminton				
Club	0.5		0.5	
Tournament	0.8		0.8	
Basketball/Volleyball				
Intramural	0.8		0.8	
College	1.3		1.3	
Professional	1.9		1.9	
Bowling				
Approach Area	0.5		0.5	
Lanes	1.1		1.1	
Boxing or Wrestling (platform)				
Amateur	2.4		2.4	
Professional	4.8		4.8	
Gymnasium				
General Exercising & Recreation Only	1.0		1.0	
Handball/Racquetball/Squash				
Club	1.3		1.3	
Tournament	2.6		2.6	
Hockey, Ice				
Amateur	1.3		1.3	
College or Professional	2.6		2.6	
Skating Rink				
Recreational	0.6		0.6	
Exhibition/Professional	2.6		2.6	
Swimming				
Recreational	0.9		0.9	
Exhibition	1.5		1.5	
Underwater	1.0		1.0	
Tennis				
Recreational (Class III)	1.3		1.3	
Club/College (Class II)	1.9		1.9	
Professional (Class I)	2.6		2.6	
Tennis, Table				
Club	1.0		1.0	
Tournament	1.6		1.6	

NOTES:
(a) Area Factor of 1.0 shall be used for these spaces.
(b) Area Factor of 1.0 shall be used for all indoor athletic spaces.
(c) Base UPD includes lighting power required for clean-up purpose.
(d) A 1.5 adjustment factor is applicable for multi-functional spaces
(e) See Section 11.0 - Definitions for Classification of Retail Facilities
(f) These Standards do not prescribe UPD for dwelling units.
(g) Area factor shall not exceed 1.55.
(h) Minimum of 90% of all work stations shall be enclosed with partitions of the height prescribed.

3.5.3.3 The Area Factor (AF) shall be determined from Figure 3.5–1 based on the floor area and ceiling height of the room. Rooms with identical ceiling height and activities, and with similar size may be treated as a group. The AF of such a group of rooms shall be determined from the average area of the rooms.

Equation 3.5–2 gives the formula used in developing Figure 3.5–1.

$$AF = 0.2 + 0.8 \text{ exp.} - \left[\left[\frac{10.21 \times (CH - 2.5)}{\sqrt{A_r}} - 1\right] \times \text{Ln } (0.9)\right]$$

Equation 3.5–2

Where:

AF=Area Factor

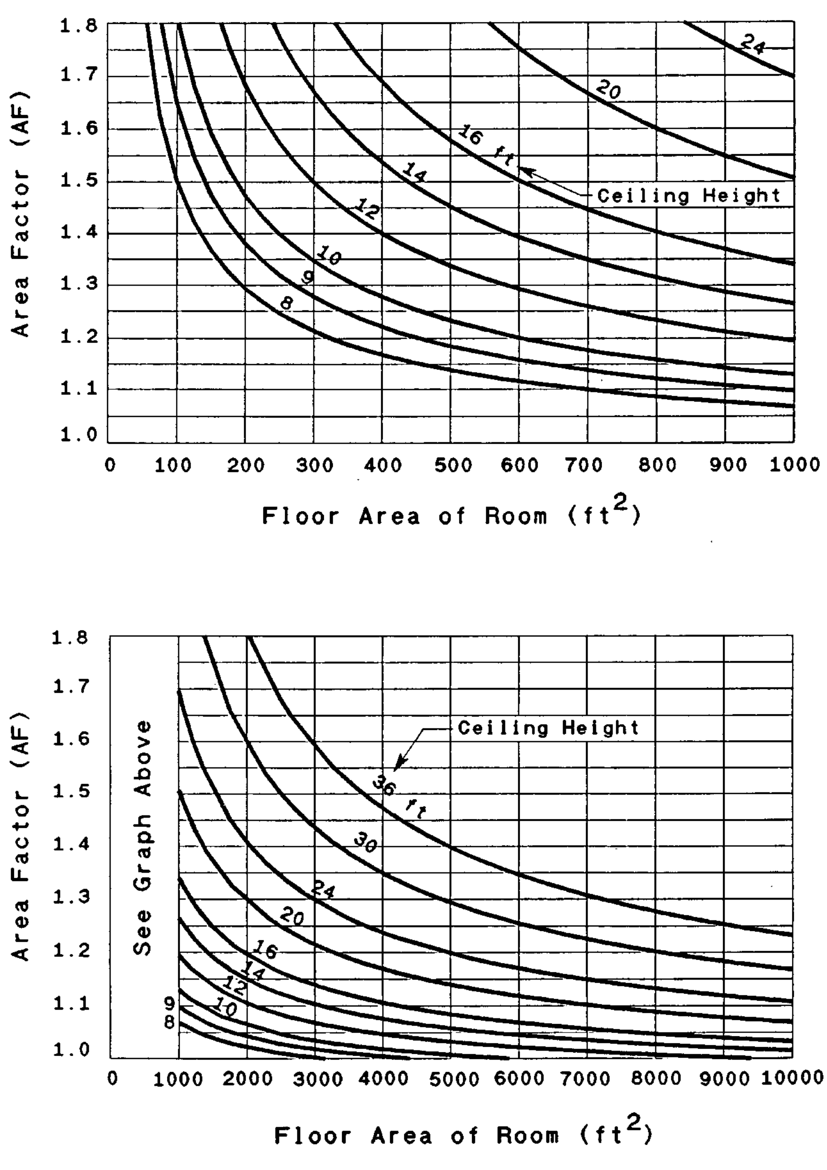
CH=Ceiling Height

A_r=Floor Area of Room, ft^2

If AF<1.0 then AF=1.0

If AF>1.8 then AF=1.8

Figure 3.5-1 Base Unit Power Density Area Factor



3.5.4 Special Spaces and Activities.

3.5.4.1 Multi-Function Rooms.

3.5.4.1.1 For rooms serving multi-functions, such as hotel banquet/meeting rooms and office conference/presentation rooms, an adjustment factor of 1.5 times the base UPD may be used if a supplementary lighting system is actually installed to serve the secondary function of the room and the design meets the following conditions:

(a) The installed power for the supplementary system shall not be greater than 33% of the adjusted LPB calculated for that room; and

(b) Independent controls shall be installed for the supplementary lighting system.

3.5.4.2 Simultaneous Activities.

3.5.4.2.1 In rooms containing multiple simultaneous activities, such as a large general office having separate accounting and drafting areas within the same room, the LPB for the rooms shall be the weighted average of the activities in proportion to the areas being served.

3.5.4.3 Indoor Sports.

3.5.4.3.1 The floor area of indoor sports activities areas shall be considered as the area within the playing boundaries of the sport, plus the floor area 10 ft beyond the playing boundaries, not to exceed the total floor area of the indoor room less the spectator seating area.

3.5.5 *Calculation of Interior Lighting Power Allowance.* The system performance Interior Lighting Power Allowance (ILPA) shall be calculated in accordance with Equation 3.5–3. The ILPA shall include a 0.20 W/ft² allowance for unlisted spaces.

$$ILPA=(LPB_1\times LS_1+LPB_2\times LS_2 —— LPB_n\times LS_n)+0.2\ W/ft^2\times(\text{Unlisted Space})$$

Equation 3.5–3

Where:

ILPA=Interior Lighting Power Allowance, W/ft²

$$\text{Unlisted space} = \frac{i-1}{\left(GLA - n\sum LS_{i-n}\right), ft^2}$$

GLA=Gross Lighted Area, ft²
LPB=Lighting Power Budget, Watts
LS=Listed Space Area, ft²

3.5.6 Lighting Power Controls Credit and Power Adjustment Factor

3.5.6.1 When calculating the ULPA in this section, the connected power for lights automatically controlled by daylighting sensors, occupancy sensor, programmable timing controls, or lumen maintenance controls may be reduced by factoring control credits on a specific area by area basis. This credit is termed the Lighting Power Controls Credit (LPCC) and shall be determined in accordance with Equation 3.5–4:

$$LPCC=CLP\times PAF$$

Equation 3.5–4

Where:

LPCC=Lighting Power Controls Credit, Watts
CLP=Connected Lighting Power for the luminaires controlled by the automatic control device, Watts
PAF=Power Adjustment Factor, from Table 3.5–2

The adjusted lighting power (ALP) is then equal to CLP minus the LPCC.

3.5.6.2 The Lighting Power Controls Credit is limited to the specific luminaires controlled by the automatic control device.

3.5.6.2.1 Only one adjustment factor may be used for each building space or luminaire, and 50% or more of the controlled luminaire shall be within the applicable space to qualify for the power adjustment factor.

3.5.6.2.2 Controls shall be installed in series with the lights and in series with all manual switching devices in order to qualify for an adjustment factor.

3.5.6.2.3 When sufficient daylight is available, daylight sensing controls shall be capable of reducing electrical power consumption for lighting, continuously or in steps, to 50% or less of maximum power consumption.

3.5.6.2.4 Daylight sensing controls shall control all luminaires to which the power adjustment factor is applied and that direct a minimum of 50% of their light output into the daylight zone.

3.5.6.2.5 Occupancy sensors located in daylighted spaces should be installed in conjunction with a manual ON switch, or photocell override for ON.

3.5.6.2.6 Programmable timing controls used for credit in conjunction with Table 3.5–2 shall be:

Table 3.5-2
Power Adjustment Factor (PAF)

AUTOMATIC CONTROL DEVICE(S)	STANDARD PAF*
(1) Occupancy sensor	0.30
(2) Daylight Sensing continuous dimming	0.30
(3) Daylight Sensing multiple step dimming	0.20
(4) Daylight Sensing ON/OFF	0.10
(5) Lumen maintenance	0.10

* - Power Adjustment Factor cannot be used for incandescent fixtures.

(a) Programmable for different schedules for occupied and unoccupied days;

(b) Accessible for temporary override by occupants of individual zones, spaces or tasks, with automatic return to the original schedules; and

(c) Capable of keeping time during power outages for a minimum of four hours.

§ 435.104 Auxiliary systems and equipment.

4.1 General

This section contains a few minimum requirements for auxiliary systems and equipment. Because auxiliary systems and equipment vary greatly among buildings, the section is not more comprehensive.

4.2 Principles of Design

4.2.1 Energy recovery should be used when coincident thermal and refrigeration loads of similar magnitude are expected.

4.2.2 Consideration shall be given to the use of waste heat, energy recovery or heat tape systems to conserve energy.

4.3 Minimum Requirements

4.3.1 Transportation Systems.

4.3.1.1 Automatic elevator and/or conveyor systems shall incorporate schedule controls and efficient motor controls, such as solid state control devices.

4.3.2 Freeze Protection System.

4.3.2.1 Boilers or water heaters used for purposes such as freeze protection in fire protection storage vessels and defrosting sidewalks and driveways shall meet the efficiency requirements of sections 8.3 or 9.3 when they operate in excess of 750 hours per year.

4.3.3 Retail Food and Food Service Refrigeration.

4.3.3.1 Refrigeration systems containing multiple compressors shall have compressors sized to optimally match capacity with loads.

4.3.3.2 Variable speed shall be considered.

§ 435.105 Building Envelope.

5.1 General

5.1.1 This section contains requirements for the energy conscious design of building envelopes. It sets principles of good envelope design, and provides a set of minimum requirements and two alternative compliance paths—prescriptive and system performance.

5.1.2 *Compliance.* A building shall be considered in Compliance with this section if the following conditions are met:

5.1.2.1 The minimum requirements of Section 5.3 are met;

5.1.2.2 The design of the building envelope complies with either the prescriptive criteria of section 5.4 or the system performance criteria of section 5.5. For the design of buildings with high internal heat gains, unusual operating schedules, or that incorporate innovative design strategies, consideration shall be given to using the compliance paths set forth in sections 11.0 or 12.0.

5.1.3 The prescriptive compliance alternative of section 5.4 provides requirements for buildings designed to take advantage of perimeter daylighting, thermal mass, high performance glazings, and fenestration shading. The designer is allowed to make trade-offs between thermal mass, wall insulation, amount of fenestration, shading coefficients, shading projections, thermal transmittance of the glazing, daylighting for several different climate locations.

5.1.4 The systems performance compliance alternative of section 3.5 provides calculation procedures that give credit for the benefits of more complex energy conserving envelope designs.

5.1.5 Information on thermal properties, performance of building envelope sections and components, and heat transfer shall be obtained from the *ASHRAE Handbook, 1985 Fundamentals Volume*. When information is not available from this source, the data shall be obtained from laboratory or field test measurements conducted in accordance with *ASTM Standard C–177–85*, ''Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Guarded Hot Plate,'' *ASTM Standard C–518–85*, ''Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter,'' *ASTM Standard C–236–80*, ''Standard Test Method for Steady-State Thermal Performance of Building Assemblies by Means of a Guarded Hot Box,'' and *ASTM Standard C–976–82*, ''Thermal Performance of Building Assemblies By Means of a Calibrated Hot Box.''

5.1.6 *Daylighting Credit*. In this section, daylighting credit for reduced energy use resulting from the use of automatic lighting control devices in conjunction with fenestration, is given only for space heating and cooling loads. Credit for the reduced use of electric lighting energy is calculated in section 3.5.6. If daylighting credit for reduced electric lighting energy use is desired to be applied to other building systems, such as more fenestration area, section 11.0 or 12.0 should be used.

5.1.7 The requirements of this section are not intended to replace building loads calculation procedures.

5.2 Principles of Design

5.2.1 Building Loads

5.2.1.1 Building loads result from sources external and internal to the building. (1) External loads, from outdoor temperature, humidity, wind, and insolation, fluctuate daily and seasonally. (2) Internal loads from the activities conducted within the building, including heating and moisture produced by the occupants, lights, and process equipment (e.g., appliances, computers) vary with internal activities. Improving energy efficiency in a building depends on achieving a balance between and among the internal and external loads. The building design should, therefore, offset gains and losses of heat, light, and moisture between the interior and exterior of the building, among interior spaces, and over-time, (daily, seasonally, and annually).

5.2.1.2 This balance of loads can be most efficiently achieved if the building envelope is viewed as, and designed to be, a controlled membrane rather than an immutable barrier. The typical design of a modern building has considered the building envelope to be a fixed barrier that restricts heat and air flow to the maximum extent possible. This will not usually yield the most energy efficient building.

5.2.1.3 The desired goal of the energy design of the building envelope shall be to produce a controlled membrane that allows or prevents heat, light, and moisture flow to achieve a balance between internal and external loads. Thus the envelope becomes an integral part of the building's environmental conditioning systems.

5.2.1.4 To achieve control of the building envelope as a membrane, and to simultaneously achieve occupant comfort in the perimeter zones, many of the traditional building skin components must be used (insulation, mass, caulking and weather stripping). However, other concepts shall also be considered to temper supply air or utilize waste heat in exhaust air to temper envelope conditions, such as operable solar shading devices, and the integration of glazing systems with the HVAC distribution system.

5.2.1.5 Control of External Loads

5.2.1.5.1 Control of Conduction

(a) Controlled conductivity may be considered through the careful use of insulation, sensible (mass) or phase-change storage and movable insulation at levels which minimizes net heating and cooling loads on a time integrated (annual) basis.

(b) Unintentional or uncontrolled thermal bridges shall be minimized and considered in energy related calculations since they can radically alter the conductivity of a building envelope. Examples include wall studs, balconies, ledges, and extensions of building slabs.

5.2.1.5.2 Control of Infiltration (Heat Loss or Gain)

(a) Infiltration shall be minimized and all efforts to achieve a zero level shall be taken. This will minimize fan energy consumption in pressurized buildings during occupied periods and heat loss (or unwanted heat gain in warm climates) during unoccupied periods. Infiltration reduction shall be accomplished through design details that enhance the fit and integrity of building envelope joints in a way that may be readily achieved during building construction. This includes infiltration control by caulking, weather stripping, vestibule doors and/or revolving doors with construction meeting or exceeding accepted specifications.

(b) The quantity of mechanical ventilation must vary with the need, with recommended values at any given time equal to that required by ASHRAE Standard 62–1981. Higher levels of ventilation (e.g., economizers) shall be considered to substitute for mechanical cooling.

(c) Operable windows may be considered to allow for occupant controlled ventilation. When using operable windows, the design of the building's mechanical system must be carefully executed to minimize unnecessary HVAC energy consumption, and building operators must be cautioned about the improper use of the operable windows.

(d) Non-mechanical ventilation can be enhanced in the shape of the building as well as the physical elements of the building envelope, such as cupolas.

(e) For hotels and high rise dwelling units and other systems having exhaust totalling 3000 cfm or more, with annual operation in excess of 3000 hours and within 200 linear ft of simultaneous make-up air equipment, they shall incorporate energy recovery or treatment to ASHRAE 62–1981 quality levels and reuse exhaust air when allowed by code.

5.2.1.5.3 Control of Radiated Heat Losses and Gains

(a) Capability for occupant radiant comfort shall be maintained regardless of whether the building envelope is designed to be a static or dynamic membrane. Opaque surfaces shall be designed so that the *average* inside surface temperatures will remain within 5 °F of room temperature in the coldest anticipated weather (i.e., winter design conditions), and the coldest inside surface will remain within 25 °F of the room temperature.

(b) In a building with time-varying internal heat generation, thermal mass may be considered for controlling radiant comfort. In the perimeter zone, thermal mass is more effective when it is positioned internal to the envelope insulation.

(c) The effective control of solar radiation is critical to the design of energy-efficient buildings due to the high level of internal heat production already present in most commercial building types. In some climates, the lighting energy consumption savings due to daylighting techniques can be greater than the heating and cooling energy penalties from additional glazed surface area, provided that the building envelope is properly designed for daylighting and lighting controls are installed and used. In other climates they may not. Daylighting designs are most effective if direct solar beam radiation is not allowed to cause glare in building spaces.

(d) The transparent portions of the building envelope shall be designed to prevent solar radiant gain above that necessary for effective daylighting and solar heating. On south-facing facades, the use of low shading coefficients is generally not as effective as external physical shading devices in achieving this balance. Light shelves offer a very effective means of admitting daylight while shading the view glazing and simultaneously allowing occupants to manipulate interior shading devices (draperies, blinds) without eliminating day light.

(e) The solar spectrum contains a range of wavelengths including visible and infrared (heat). Designers shall consider which portion of the spectrum to admit into the building. For example, low emissivity, high-visible-transmittance glazings may be considered for the effective control of radiant heat gains and losses. For shading control designers may consider the careful use of vegetation that can block excess gain, year-around or seasonally depending on the plant species chosen.

5.3 Minimum Requirements

5.3.1 Overall Thermal Transmittance (U_o)

5.3.1.1 The overall thermal transmittance of the building envelope above grade assembly shall be calculated as follows:

$$U_o = \sum U_i A_i / A_o = (U_1 A_1 \times U_2 A_2 + \cdots + U_n A_n) / A_o$$

Equation 5.3–1

Where:

U_o=the area weighted average thermal transmittance of the gross area of the building envelope assembly, e.g., the exterior wall assembly including fenestration and doors; roofs and ceiling assembly; or the floor assembly, Btu/h•ft²•°F.

A_o=the gross area of the envelope assembly, ft².

U_i=the thermal transmittance of each individual path of the envelope assembly (see Section 5.3.2), U_i=1/R_i (where R_1 is the total resistance to heat flow of an individual path through an envelope assembly).

A_i=the area of each individual element of the envelope assembly, ft².

5. 3. 2 *Thermal Resistance of Below Grade Components (R)*

5.3.2.1 In calculating the thermal resistance of all below grade components, the thermal performance of the adjacent ground shall be excluded.

5.3.2.2 *Slabs*

5.3.2.2.1 The R-value required for slabs refers only to the insulation materials. Insulative continuity shall be maintained in the design of slab edge insulation systems. Continuity shall be maintained from the wall insulation through the slab/wall/footing intersection to the body of the slab edge insulation.

5.3.2.2.2 Slab-on-grade floors shall have insulation around the perimeter of the floor with the thermal resistance (R_u) of the insulation specified in accordance with Figure 5.5–2. The slab insulation specified shall extend either in a vertical plane downward from the top of the slab for the minimum distance shown or downward to the bottom of the slab then in a horizontal plane beneath the slab or outward from the building for the minimum distance shown. The horizontal length, or vertical depth, of insulation required varies from 24 in. to 48 in. depending upon the R-value selected. For heated slabs, an R of 2 shall be added to the thermal resistance required.

5.3.2.2.3 Vertical insulation shall not be required to extend below the foundation footing. There are no insulation requirements for slabs in locations having less than 3,000 HDD65 or for footings extending less than 18 in. below grade.

5.3.2.2.4 The dimensional requirements for horizontal insulation refers to the insulation materials only. Horizontal applications shall have a thermal break in the slab edge that provides continuity between the wall insulation on the slab and the horizontal insulation.

Below Grade Walls

5.3.2.3.1 The R-value required for Below Grade Walls refers to the overall R-value of the wall assembly excluding air film coefficients and the thermal performance of the adjacent ground.

5.3.3 Thermal Transmittance (U_i) of an Envelope Assembly

5.3.3.1 The thermal transmittance of each envelope assembly shall be determined with due consideration of all major series and parallel heat flow paths through the elements of the assembly. Compression of insulation shall be considered in determining the thermal resistance.

5.3.3.2 The thermal transmittance of opaque assemblies U_i shall be determined using a series path procedure that corrects parallel paths, such as insulation and studs in a wall cavity or the roof assembly shown in Figure 5.3–1. Table 5.3–1 prescribes the procedure to be used for Subsections 5.3.3.2.1 and 5.3.3.2.2.

Figure 5.3-1
Example of Total Resistance of an Envelope Assembly
Including Series Resistance and Parallel Path Equivalent
Resistance Elements

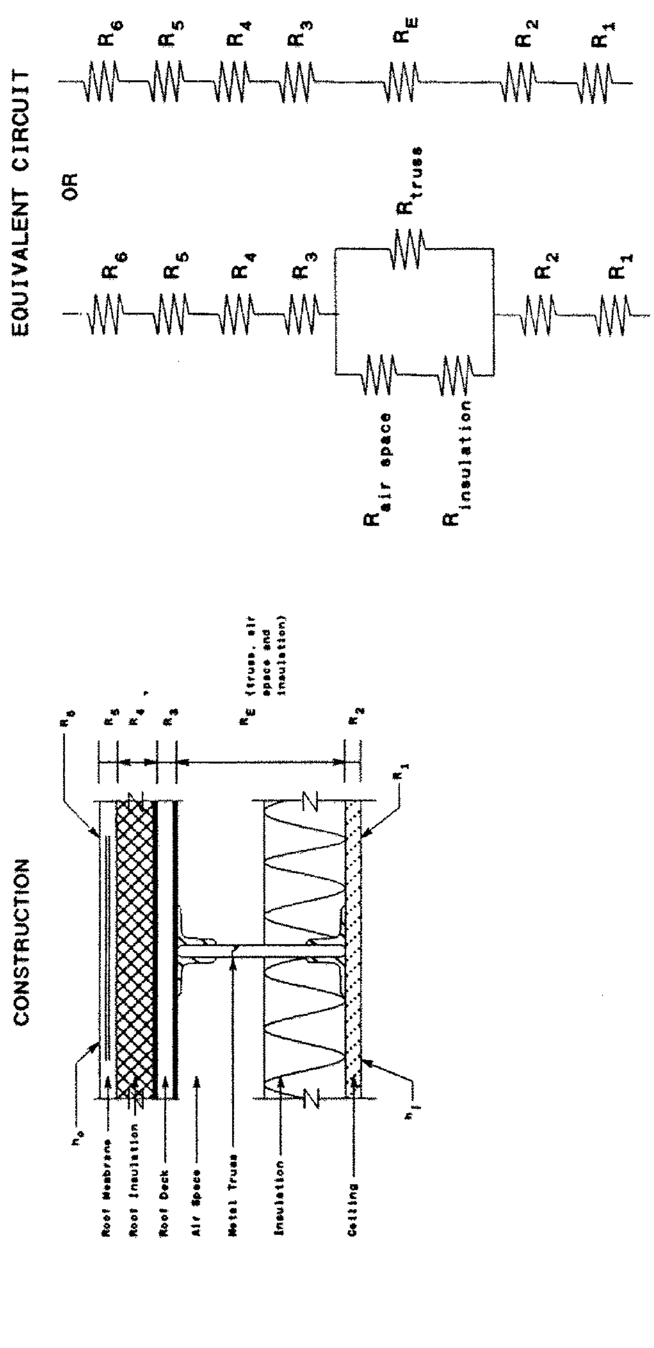


Table 5.3-1

Calculation Procedures for Thermal Transmittance Through Opaque Envelope Assemblies

Material Attached To Thermal Bridge Material	Thermal Bridge Material	Calculation Procedure(s)
Metal	Metal	Thermal Bridges Sheet Metal Construction, 5.3.3.2.1 (d)
Metal	Non-Metal	Parallel/Series 5.3.3.2.2
Non-Metal	Metal	Case Specific Correction 5.3.3.2.1 (b), or 5.3.3.2.1 (c)
Non-Metal	Non-Metal	Parallel/Series 5.3.3.2.2

5.3.3.2.1 For envelope assemblies containing metal framing, the U_i shall be determined by using one of the following methods:

(a) Results from laboratory or field test measurements, using one of the procedures specified in section 5.1.5.

(b) For non-metal surfaces attached to metal framing, where data from tests conducted using procedures specified in section 5.1.5, such as those provided in Tables 5.3–2 and 5.3–3, is available, the total resistance of the series path may be calculated using Equations 5.3–2a and 5.3–2b, and illustrated in Figure 5.3–1:

Table 5.3-2

Parallel Path Correction Factors[1]

Bridged R-Value	0	5	10	15	20	25	30	35	40	45	50	55
Correction Factor	1.0	0.96	0.92	0.88	0.85	0.81	0.79	0.76	0.73	0.71	0.69	0.67

1. Table 5.3-2 values are based upon metal trusses with 4 ft spacing that penetrate the insulation, and 0.66 in. diameter crossmembers every 1 ft.

Table 5.3-3
Wall Sections With Metal Stops
Parallel Path Correction Factors

Size of Members	Gauge of Stud	Spacing of Framing, In.	Cavity Insulation R-Value	Correction Factor
2 X 4	18-16	16 o.c.	R-11	0.50
2 X 4	18-16	24 o.c.	R-11	0.60
2 X 6	18-16	16 o.c.	R-19	0.40
2 X 6	18-16	24 o.c.	R-19	0.45

$$U_i = 1/R_t$$

Equation 5.3–2a

$$R_t = R_i + R_e$$

Equation 5.3–2b

Where:

R_t=the total resistance of the envelope assembly

R_i=the resistance of the series elements (for i=1 to n), excluding the parallel path element(s)

R_e=the equivalent resistance of the element containing the parallel path, the value of R_e is:

R_e=(R-value of insulation)×F_c

Equation 5.3–2c

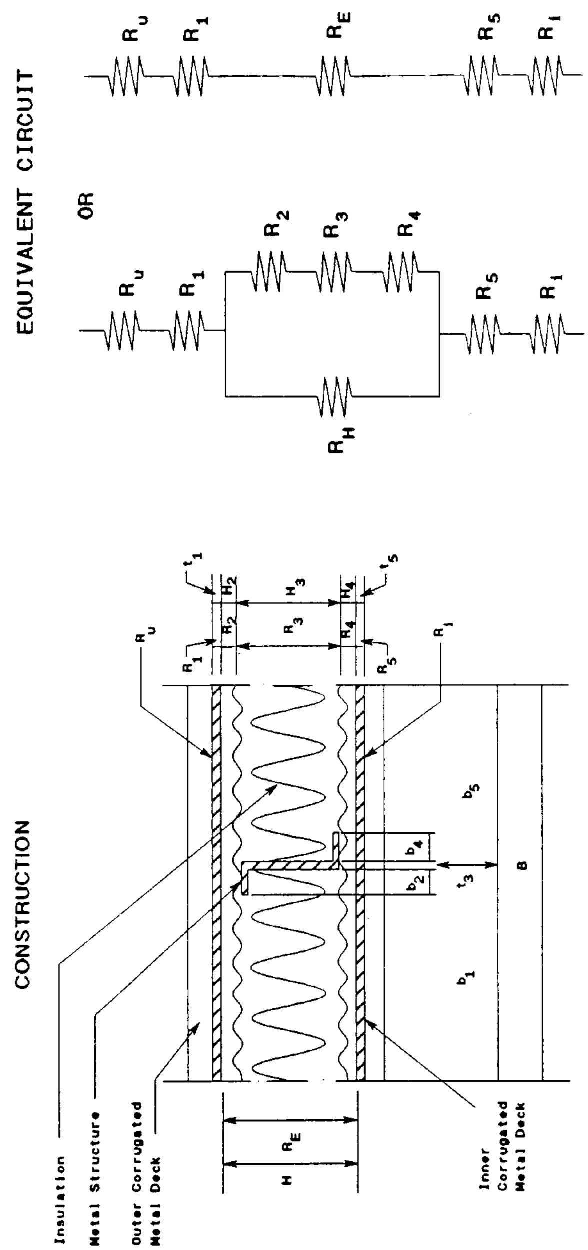
Where:

F_c=the correction factor from Table 5.3–2 or Table 5.3–3.

(c) For elements other than those covered in item (b) above, the zone method described in Chapter 23 of the *ASHRAE Handbook, 1985 Fundamentals Volume* shall be used. The equations on pages 23.13 and 23.14 shall be used.

(d) For sheet metal construction, internally insulated with an internal metal structure bonded on one or both sides to a metal skin or covering (see Figure 5.3–2), the following steps shall be used to calculate the U-value of the envelope construction.

Figure 5.3-2
A Generalized Built-Up Sheet Metal
Construction and Corresponding Resistance Network



(1) First, calculate the resistance of the thermal bridge R_{TB} as follows:

$$R_{TB} = R_1 + R_2 + R_3 + R_4 + R_5$$

(i) Where R_1, the effective mean flow path along the outer metal surface, is calculated by:

$$R_1 = \frac{1}{2 \times L\sqrt{h_1 k_1 T_1}} - \frac{1}{B \times L \times h_1}$$

(ii) And if it occurs, the resistance of insulation (R_2) between the outer metal surface and the metal structural member is calculated by:

$$R_2 = \frac{1}{k \times L\left[\frac{b_2}{H_2} + \frac{2}{\pi}\right]}$$

(iii) And, the resistance of the structural member (R_3) is calculated by:

$$R_3 = \frac{h_3}{L \times t_3 \times k_3}$$

Equation 5.3–6

(iv) And if it occurs, the resistance of insulation (R_4) between the inner metal surface and the purlin flange is calculated by:

$$R_4 = \frac{1}{k \times L\left[\frac{b_4}{H_4} + \frac{2}{\pi}\right]}$$

(v) And finally, the effective mean flow path along the inner metal surface (R_5) is calculated by:

$$R_5 = \frac{1}{2 \times L\sqrt{h_5 k_5 T_5}} - \frac{1}{B \times L \times h_5}$$

Where:
L=total length
h=coefficient of heat transfer
k=thermal conductivity
T=temperature
B=total width
H=partial height
t=thickness of sheet metal

(2) Then calculate the parallel path resistance of the homogeneous insulation R_H as follows:

$$R_H = \frac{\Sigma\left[\frac{H}{K}\right]}{B \times L}$$

(3) Then obtain the overall construction resistance R_C by combining R_H and R_{TB} as two parallel resistances:

$$R_C = \frac{R_{TB} \times R_H}{R_{TB} + R_H}$$

Equation 5.3–10

(4) Then add the inside and outside surface resistances R_i and R_u to get the total resistance $R_{TOT \leqq}$

$$R_{TOT} = R_C + R_i + R_u$$

Equation 5.3–11

(5) The total area resistance m_{TOT} is then calculated by:

$$m_{TOT} = R_{TOT} \times B \times L$$

Equation 5.3–12

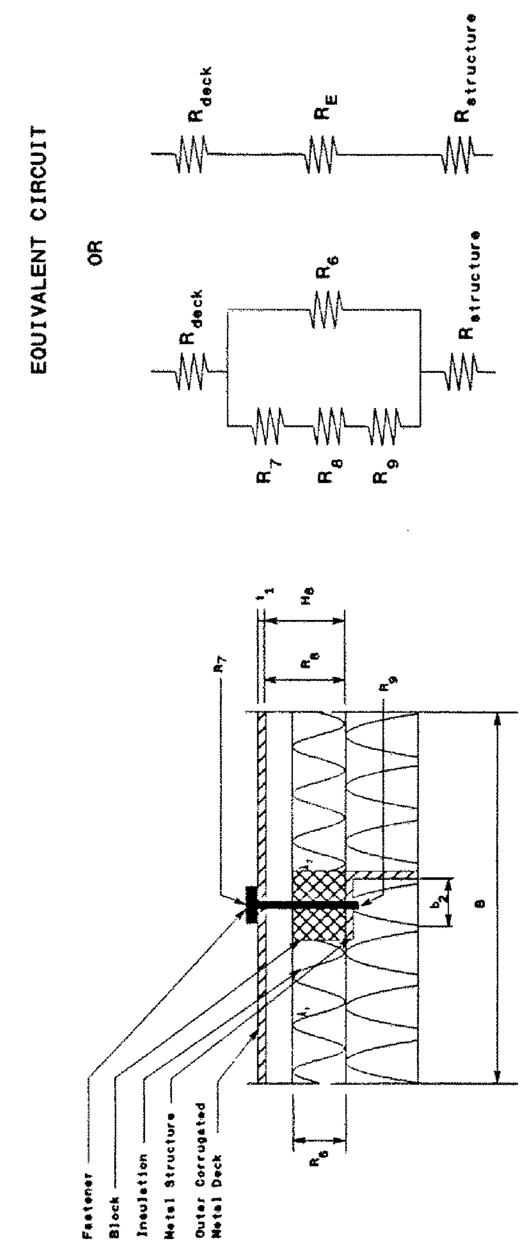
(6) And finally, obtain the U-value by:

$$U = \frac{1}{m_{TOT}}$$

Equation 5.3–13

(7) Where additional resistances are introduced in the construction, introduce them in lieu of the above (R_2 and R_4) resistances. An example of this would be the calculation of both a metallic fastener and a block of higher thermal conductivity material between the outer sheet metal and the internal structural member as shown in Figure 5.3–3. In this case the original R_2 is recalculated by first calculating the thermal bridge R_{2TB} as follows:

Figure 5.3-3
Detail of Heat Transfer From a Metal Surface to a Structure Through a Metal Fastener and Insulating Block With Corresponding Resistance Network



$$R_{2TB} = R_7 + R_8 + R_9$$

Equation 5.3–14

(i) Where the resistance of the heads of number (N) of fasteners per length

(L), adjusting for surface resistance in common with the sheet metal surface, is calculated by:

$$R_7 = \frac{1}{N \times 2 \times \pi \times \lambda_1 \times t_1 \times f\left(\beta r_1, \infty\right)} - \frac{1}{a_1 \times B \times L}$$

Equation 5.3–15

Where:

N=the number of fasteners in Length L

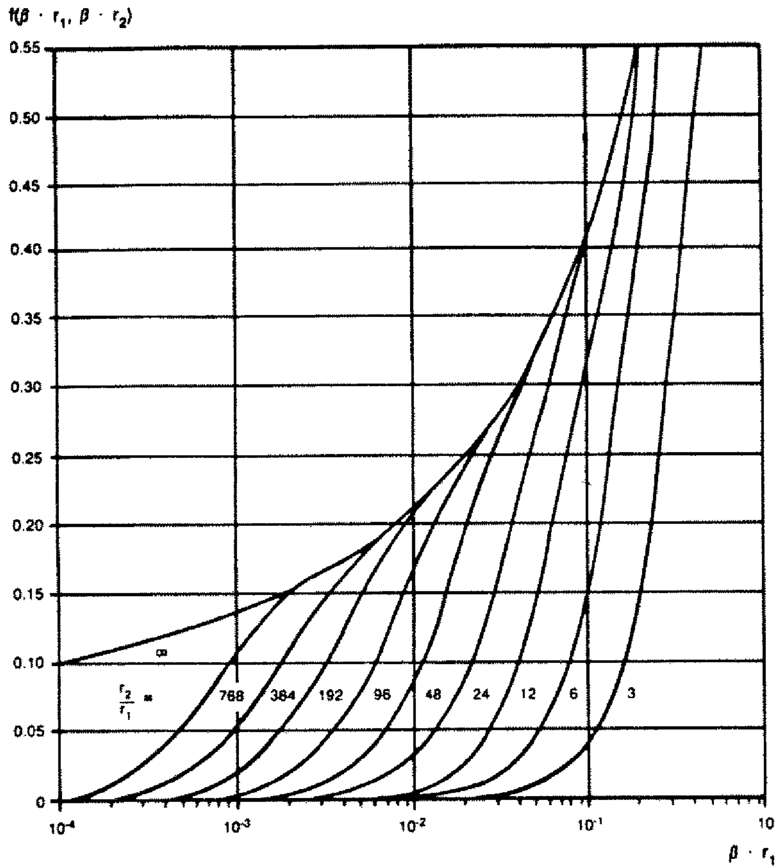
f=the function of B&divide≧ r for different values of the ratio r_2/r_1 given in Figure 5.3–4.

$$\# = \sqrt{\ } = \frac{\sqrt{h}}{\lambda x t}$$

r_1=the radius of the fastener shank.

r_2=the outer radius of the fastener head.

Figure 5.3-4 – The Function (f) Given as a Function of βr and for Different Values of the Ratio, r_1/r_2



(ii) And, the resistance of the shank of the fastener is calculated by:

$$R_8 = \frac{H_8}{N \times \lambda \times \pi \times r^2{}_1}$$

Equation 5.3–16

(iii) And, finally, the resistance of the connection to the internal structural member is calculated by:

$$R_9 = \frac{1_n \times \frac{b_2}{r_1}}{N \times 2\pi\lambda \times t}$$

(iv) Then calculate the resistance of the block of higher thermal conductivity material as follows:

$$R_6 = \frac{1}{L_1\left[\lambda_1 \frac{b}{H_8} + \lambda_2 \frac{2}{\pi}\right]}$$

Where:

λ1λ2

(v) Then obtain the resistance to be used in lieu of the original R_2 by:

$$R_2 = \frac{R_{TB} \times R_6}{R_{TB} + R_6}$$

Equation 5.3–19

5.3.3.2.2 For envelope assemblies containing Non-Metal Framing, the U_i shall be determined from one of the laboratory or field test measurements specified in Section 5.1.5 or from the ASHRAE series-parallel method. Formulas in Chapter 23, page 23.2 of the *ASHRAE Handbook, 1985 Fundamentals Volume,* shall be used for these calculations.

5.3.3.3 The thermal transmittance of fenestration assemblies shall be corrected to account for the presence of sash, frames, edge effects and spacers in multiple-glazed units.

If thermal transmittances of sash and frames are known, Equation 5.3–1 shall be used, otherwise the thermal transmittance offenestration assemblies shall be calculated as follows:

$U_{of}=\Sigma\ U_{gi}\times F_{f,i}\times A_i/A_{of}=$
$(U_{g,1}\times F_{e,1}\times A_1+U_{g,2\times Ff,2}\times A_2+\ldots$
$+U_{g,n}\times F_{f,n}\times A_n)/A_{of}$

Equation 5.3–20

Where:

A_i=area of i^{th} fenestration assembly
i=numerical subscript (1,2,. . . n) refers to each of the various fenestration assemblies present in the wall
n=the number of fenestration assemblies in the wall assembly.
U_{of}=the overall thermal transmittance of the fenestration assembly, including sash and frames, Btu/h•ft²°F.
U_g=the thermal transmittance of the central area of the fenestration excluding edge effects, spacers in multiple-glazed units, and the sash and frame, Btu/h•ft²°F.
$F_{f,i}$=framing adjustment factor for sash, frames, etc.
A_{of}=the area of all fenestration including glazed portions, sash, frames, etc.

5.3.3.3.1 Values for U_g shall be the winter value obtained from the glazing manufacturer's test data or from Table 13 or Figure 14 of Chapter 27 of the *ASHRAE Handbook, 1985 Fundamentals Volume.* Values for F_f shall be obtained from the frame manufacturer's test data or from the average adjustment factor for a particular product in Table 13, Part C, in Chapter 27 of the *ASHRAE Handbook, 1985 Fundamentals Volume.* For glass products with a U value of 0.45 or less, use the F_f for triple insulated glazing. Alternatively, values of the U_g°F product may be used from manufacturer's test data for open window and frame assemblies tested as a unit provided that the tests referenced edge-effects and windspeed are accounted for winter tested U-values are used.

5.3.4 Gross Area of Envelope Components

5.3.4.1 The gross area of a roof assembly consists of the total surface of the roof assembly exposed to outside air or unconditioned spaces. The roof assembly shall include all roof/ceiling components through which heat may flow between indoor and outdoor environments including skylight surfaces, but excluding service openings.

5.3.4.1.1 For thermal transmittance purposes, when return air ceiling plenums are employed, the roof/ceiling assembly shall not include the thermal resistance of the ceiling, or the plenum space, as part of the total thermal resistance of the assembly.

5.3.4.2 The gross area of a floor assembly over outside or unconditioned space consists of the total surface of the floor assembly exposed to the outside air or an unconditioned space. The floor assembly shall include all floor components through which heat may flow between indoor and outdoor or unconditioned space environments.

5.3.4.3 The gross area of exterior walls enclosing a heated or cooled space is measured on the exterior and consists of the opaque wall including between floor spandrels, peripheral edges of flooring, window areas including sash and door areas, but excluding vents, grilles and pipes.

5.3.5 Shading Coefficients

5.3.5.1 The Shading Coefficient (SC) for fenestration shall be obtained from Chapter 27 of the *ASHRAE Handbook,* *1985 Fundamentals Volume* or from manufacturers' test data. For the prescriptive or system performance envelope compliance calculations in sections 5.4 and 5.5, a factor, SC_x, is used. SC_x is the Shading Coefficient of the fenestration, including internal and external shading devices, but excluding the effect of external shading projections, which is calculated separately. The shading coefficient used for louvered shade screens shall be determined using a profile angle of 30°, as found in Table 41, Chapter 27 of the *ASHRAE Handbook, 1985 Fundamentals Volume.*

5.3.6 Wall Heat Capacity

5.3.6.1 Heat capacity in Btu/°F•ft², shall be determined as the product of the average wall weight in lb/ft² and the weighted average specific heat of the wall component in Btu/lb•°F.

5.3.6.2 If the wall system is defined as having exterior insulation only the properties of the wall elements inside of the insulation layer shall be used in determining the wall heat capacity.

5.3.6.3 For walls with integral insulation, all of the elements of the entire wall system may be used in the calculation of the wall heat capacity.

5.3.7 Air Leakage and Moisture Migration

5.3.7.1 The requirements of this subsection apply only to those locations separating the outdoors from interior building conditioned space. Compliance with the criteria for air leakage through building components shall be determined by *ASTM E 283–1984*, ''Standard Method of Test Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors.''

5.3.7.2 Air Leakage Requirements for Fenestration and Doors

5.3.7.2.1 Fenestration meeting the following standards for air leakage is acceptable:

(a) *ANSI/AAMA 101–85*, ''Aluminum Prime Windows.''

(b) *ASTM D–4099–83*, ''Specifications for Poly(VinylChloride) (PVC) Prime Windows.''

(c) *ANSI/NWMA I.S. 2–80*, ''Wood Window Units (Improved Performance Rating Only).''

5.3.7.2.2 Sliding Doors shall meet one of the following standards for air leakage:

(a) *ANSI/AAMA 101–85*, ''Aluminum Sliding Glass Doors.''

(b) *NWMA I.S. 3–83*, ''Wood Sliding Patio Doors.''

5.3.7.2.3 Commercial entrance swinging or revolving doors shall limit air leakage to a rate not to exceed 1.25 cfm/ft² of door area, at standard test conditions.

5.3.7.2.4 Residential swinging doors shall limit air leakage to a rate not to exceed 0.5 cfm/ft² of door area, at standard test conditions.

5.3.7.2.5 Where spaces have regular high volume traffic through the building envelope, such as retail store entrances and loading bays, estimates of air leakage for HVAC system design shall be based on air exchange by traffic flow.

5.3.7.2.6 To reduce infiltration due to stack-effect draft in multi-story buildings, the use of vestibules or revolving doors on all primary entries and exits shall be considered.

5.3.7.3 Air Leakage Requirements for Exterior Envelope Joints and Penetrations.

5.3.7.3.1 Exterior joints, cracks, and holes in the building envelope, such as those around window or door frames, between wall and foundation, between wall and roof, through wall panels at penetrations of utility services or other service entry through walls, floors, and roofs, between wall panels, particularly at corners and changes in orientation, between wall and floor, where floor penetrates wall, around penetrations of chimney, flue vents, or attic hatches, shall be caulked, gasketed, weather stripped, or otherwise sealed.

5.3.7.4 Moisture Migration Requirements for Exterior Envelopes

5.3.7.4.1 The building envelope shall be designed to prevent moisture migration that leads to deterioration in insulation performance of the building.

5.3.7.4.2 Vapor retarders shall be considered to prevent moisture from collecting within the envelope. Designs should incorporate the principles of *ASHRAE Handbook, 1985 Fundamentals Volume*, Chapter 21, ''Moisture in Building Construction.''

5.3.8 Shell Buildings

5.3.8.1 The following conditions shall be assumed if determination of building envelope compliance occurs prior to the determination of lighting power density, equipment power density, or fenestration shading device characteristics:

5.3.8.1.1 *Lighting Power Density and Equipment Power Density.* For section 5.4, the total power density shall be assumed to be those listed in Table 5.3–4. For section 5.5, the values in Table 5.3–4 shall be assumed to be apportioned as ⅔ lighting and ⅓ for other equipment. Note that these are not recommended design values, but are for compliance purposes only.

Table 5.3-4
Assumed Internal Loads For Shell And Speculative Buildings

	HDD65<3000	3000<HDD65<6000	HDD65>6000
Shell Buildings	3.0 W/Ft^2	2.25 W/ft^2	1.50 W/ft^2
Speculative Buildings	Use the ULPA from Table 3.4-1 and the average equipment power density from Table 5.4-32.		

5.3.8.1.2 *Fenestration shading devices.* Only those shading devices that are part of the design when it is being evaluated for compliance shall be considered when determining compliance.

5.3.8.1.3 *Daylighting controls for electric lighting.* Only those controls that are part of the design when it is being evaluated for compliance shall be considered when determining compliance.

5.3.9 Buildings Located in Climates With Greater Than 15,000 HDD Base 65 °F.

5.3.9.1 For locations with a heating degree-day base (HDD) 65 °F greater than 15,000, the envelope criteria listed in Table 5.3–5 shall apply, and the window wall ratio (WWR) shall be less than or equal to 0.20.

Table 5.3-5
Requirements For Locations With
Heating Degree-Days Base 65 °F Greater Than 15,000

Envelope Statement	Maximum U Value	Minimum R Value	Notes
U_o opaque wall for buildings with $\geq$ 12,000 ft^2 of gross floor area [1,3]	0.053		See 5.3.3.2
U_o opaque wall for buildings with < 12,000 ft^2 of gross floor area [2,3]	0.040		
U fenestration	0.450		Use Eq 5.3-20
U roof	0.024		
Floor over unconditioned spaces[4]	0.023		See 5.3.3.2
Wall below grade[5]		18	

Slab-on-grade:

Position	Minimum Insulation Distance, in.	Minimum R Value: Unheated Slab	Minimum R Value: Heated Slab
Horizontal	48	15	17
Vertical	48	6	8

Skylights: Not allowed for locations with HDD65 greater than 15,000.

Footnotes for Table 5.3-5:

1. For window to wall ration, WWR $\leq$ 0.20. Shall include corrections for parallel paths within the envelope assembly. For WWR > 0.20, see Footnote (3).
2. For window to wall ratio, WWR $\leq$ 0.15. Shall include corrections for parallel paths within the envelope assembly. For WWR > 0.15, see Footnote (3).
3. The window to wall ratio and the stated U-values for opaque wall and fenestration may be increased or decreased provided that the combined thermal wall transmittance shall not exceed 0.125 for buildings $\geq$ 12,000 ft^2, and 0.091 for buildings < 12,000 ft^2.
4. Including pile-supported floors and elevated floors.
5. Installed on the exterior of perimeter foundation walls for heated foundations.

5.3.10 Daylight Credits for Skylights.

5.3.10.1 Skylights used in conjunction with automatic lighting controls for daylighting can significantly reduce the lighting energy consumption, thereby more than offsetting the increase in envelope heat transfer.

5.3.10.2 When determining building roof compliance, daylight credits for skylights may be used if the criteria of this subsection are met.

5.3.10.3 Skylights for which daylight credit is taken may be excluded from the calculation of the overall thermal transmittance value (U_{or}) of the roof assembly, if all of the following conditions are met:

5.3.10.3.1 The opaque roof thermal transmittance U_{or} value does not exceed the value determined within the selected Alternate Component Package (ACP) table for the prescriptive method or by Equation 5.5–1 for the systems performance method.

5.3.10.3.2 Skylight areas, including framing, as a percentage of the roof area do not exceed the values specified in Tables 5.3–6A and 5.3–6B for building sites located within the climate ranges listed in the two Tables, where Visible Light Transmittance (VLT) is the transmittance of a particular glazing material over the visible portion of the solar spectrum. Skylight areas shall be interpolated between visible light transmittance values of 0.75 and 0.50, only.

Table 5.3-6a
(VLT = 0.75)
Maximum Percent Skylight Area for Given Conditions of Lighting Power Density, Light Level (fc), HDD65 and CDH80

BUILDING LOCATION		LIGHT LEVEL IN (fc)	Range of Lighting Power Density (W/ft^2)				
HDD65	CDH80		<1.00	1.01-1.50	1.51-2.00	2.01-2.50	>2.50
0-3000	0-10000	30	2.3	3.1	3.9	4.7	4.7
		50	3.1	4.3	5.5	6.7	6.7
		70	4.3	5.5	6.7	7.9	7.9
0-3000	>10000	30	2.2	2.8	3.4	4.0	4.0
		50	2.3	3.1	3.9	4.7	4.7
		70	2.9	4.1	5.3	6.5	6.5
>3000	ALL	30	2.3	3.4	4.5	5.6	5.6
		50	2.5	4.0	5.5	7.0	7.0
		70	2.8	4.6	6.4	8.2	8.2

Table 5.3-6b
(VLT = 0.50)
Maximum Percent Skylight Area for Given Conditions of Lighting Power Density, Light Level (fc), HDD65 and CDH80

BUILDING LOCATION		LIGHT LEVEL IN FC	Range of Lighting Power Density (W/ft^2)				
HDD65	CDH80		<1.00	1.0-1-1.50	1.51-2.00	2.01-2.50	>2.50
0-3000	0-10000	30	3.6	4.8	6.0	7.2	7.2
		50	4.8	6.6	8.4	10.2	10.2
		70	6.6	8.4	10.2	12.0	12.0
0-3000	>10000	30	3.3	4.2	5.1	6.0	6.0
		50	3.6	4.8	6.0	7.2	7.2
		70	4.2	6.0	7.8	9.6	9.6
>3000	ALL	30	3.6	5.1	6.6	8.1	8.1
		50	3.9	6.0	8.1	10.2	10.2
		70	4.2	6.9	9.6	12.3	12.3

5.3.10.3.3 The skylight area associated with daylight credit can be taken is the area under each skylight whose dimension in each direction (centered on the skylight) is equal to the skylight dimension in that direction plus a distance equal to the floor to ceiling height.

5.3.10.3.4 Skylight areas that overlap areas that have already taken daylight credit (perimeter window areas or other skylight areas) do not again take daylight credit.

5.3.10.3.5 All electric lighting fixtures within skylight areas are controlled by daylight-activated automatic lighting controls.

5.3.10.3.6 For buildings located in climates that have less than 8000 HDD65, the overall thermal transmittance of the skylight assembly, including framing, is less than or equal to 0.7 Btu/h•ft^2•°F. For locations greater than 8000 HDD65, the overall thermal transmittance of the skylight assembly, including framing, is less than or equal to 0.45 Btu/h•ft^2•°F.

5.3.10.3.7 Skylight curbs have thermal transmittance (U) values no greater than 0.21 Btu/h•ft^2•°F.

5.3.10.3.8 The infiltration coefficient of the skylights does not exceed 0.05 cfm/ft^2.

5.3.10.4 Skylight areas in Tables 5.3–6A and 5.3–6B may be increased by 50% if a shading device is used that blocks over 50% of the solar gain during the peak cooling design condition.

5.3.10.5 Areas for vertical glazing in clerestories and roof monitors shall be included in the wall fenestration calculation.

5.3.10.6 For shell buildings, the permitted skylight area from Tables 5.3–6A and 5.3–6B shall be based on a light level of 30 fc and a lighting power density (LPD) of less than 1 W/ft^2.

5.3.10.7 For speculative buildings, the permitted skylight area from Tables 5.3–6A and 5.3–6B shall be based on the unit lighting power allowance from Table 3.4–1 and an illuminance level as follows:

5.3.10.7.1 For LPD less than or equal to 1.0 W/ft^2, use 30 fc;

5.3.10.7.2 For LPD greater than 1.0 W/ft^2 and less than 2.5 W/ft^2, use 50 fc; and

5.3.10.7.3 For LPD greater than 2.5 W/ft^2, use 70 fc.

5.3.10.8 Buildings with roof assembly devices that cannot be evaluated under this subsection shall be evaluated using the Building Energy Compliance Methods of Section 11.0 or 12.0.

5.4 Building Envelope—Prescriptive Compliance Alternative

5.4.1 General.

5.4.1.1 This section provides a simple compliance path using precalculated prescriptive requirements for selected exterior envelope configurations of new buildings.

5.4.1.2 The Alternate Component Packages (ACP), found in this subsection, provide design criteria for use with the following options:

5.4.1.2.1 ''Base Case''—buildings with envelopes designed without perimeter daylighting.

5.4.1.2.2 ''Perimeter Daylighting''—buildings with envelopes that use additional fenestration area by incorporating automatic lighting controls in the perimeter zone to permit the use of daylighting in lieu of electric lighting. This ACP is not available for those climates that do not usually require space cooling by means of mechanical refrigeration.

(a) This daylighting credit is in addition to the increased lighting power allowance provided in section 3.5. Some perimeter daylighting options allow a greater proportion of fenestration area due to the increased visible and decreased thermal transmittances of high performance glazings in combination with automatic lighting controls.

5.4.1.3 Each ACP provides a limited number of complying combinations of building variables for a set of climate ranges. The criteria, such as maximum percent fenestration, were calculated using the system performance criteria of section 5.5. Values were chosen from within climate and other variable ranges for the most restrictive results, to ensure compliance of any combination of values within those ranges. Thus, for most climate locations and envelope parameters, the prescriptive criteria may be slightly more stringent than the system performance criteria of section 5.5.

5.4.1.4 Both the base and perimeter daylight cases have two or three fenestration U-value ranges depending on the climate.

5.4.2 Compliance.

5.4.2.1 The envelope design of the building being evaluated is in compliance with the prescriptive criteria of this section provided that:

5.4.2.1.1 The minimum requirements of section 5.3 are met.

5.4.2.1.2 All envelope thermal transmittance (U) values are less than or equal to those chosen from the ACP Table selected for roofs, opaque walls, walls next to unconditioned spaces, and floors over unconditioned spaces.

5.4.2.1.3 The percentage of fenestration of the combined gross wall area is less than or equal to the value permitted for internal load range and glazing in the selected ACP Table.

5.4.2.1.4 Slab-on-grade floors have insulation around the perimeter of the floor with the thermal resistance (R_u) of the insulation as listed in the ACP table. The slab insulation specified shall extend either in a vertical plane downward from the top of the slab for the minimum distance shown or downward to the bottom of the slab then in a horizontal plane beneath the slab or outward from the building for the minimum distance shown. The horizontal length, or vertical depth, of insulation required varies from 24 in. to 48 in. depending upon the R-value selected. For heated slabs, an R of 2 shall be added to the thermal resistance required.

(a) Vertical insulation shall not be required to extend below the foundation footing.

(b) There are no insulation requirements for slabs in locations having less than 3,000 HDD65 or for footings extending less than 18 in. below grade.

5.4.2.1.5 The thermal resistance of the below-grade wall assembly must be greater than or equal to that listed in the ACP table, or the heat loss calculated in accordance with Chapter 25 of the *ASHRAE Handbook, 1985 Fundamentals* shall be less than or equal to that of a wall below grade having a thermal resistance equal to that specified in Figure 5.5–3. No insulation is required for climates with less than 3,000 HDD65 or for those portions of walls more than one story below grade.

5.4.3 Procedure for Using the Alternate Component Packages (ACP).

5.4.3.1 The prescriptive envelope criteria for each of 30 climate ranges are contained in Tables 5.4–2 through 5.4–31.

5.4.3.2 The following steps shall be used to determine compliance with these prescriptive envelope criteria.

5.4.3.2.1 Determine appropriate climate range using either (a) or (b) below.

(a) From Table 5.4–1, select the appropriate ACP Table based on the climate for the building site. The main climate variables that are needed for the proper selection of an ACP Table are cooling degree-days base 65 °F (CDD65), heating degree-days base 50 °F (HDD50), and annual average daily incident of solar radiation on the east or west vertical surface of the facade, Btu/ft^2/day (VSEW). For certain climate ranges this must be augmented by cooling degree-hours base 80 °F (CDH80).

(1) This data, for a specific building location, may be acquired from the U.S. Weather Service of the National Oceanic and Atmospheric Administration or the local weather bureau. The column designated ''ACP Table No.'' in Table 5.4–1 contains the table number of the appropriate ACP Table.

Table 5.4-1
Climate Data Grouped by ACP Tables

ACP Table Number	HDD50 Range	CDD65 Range	VSEW Range	CDH80 Range	Example Cities
5.4-2	0	3001-4500	>800		Barbers Point, Hilo, Honolulu, Lihue
5.4-3	0	>4500	>845		Guantanamo Bay, Kwajalein, San Juan, Wake Island
5.4-4	1-1000	0-1150	560-845		Arcata, North Bend
5.4-5	1-1000	0- 300	>845		Oakland, San Francisco, Santa Maria, Sunnyville
5.4-6	1-1000	301-1150	>845		El Toro, Long Beach, Los Angeles, San Diego
5.4-7	1-1000	1151-2000	560-845		Atlanta, Augusta, Birmingham, Cherry Point, Greenville
5.4-8	1-1000	1151-2000	>845		Fresno, Red Bluff, Sacramento
5.4-9	1-1000	2001-3250	560-845		Charleston, Houston, Jackson, Montgomery, New Orleans
5.4-10	1-1000	2001-3250	>845	0-18000	Austin, Bakersfield, El Paso, Fort Worth, Tallahassee, Tampa
5.4-11	1-1000	2001-3250	>845	>18000	China Lake, Las Vegas, Tucson
5.4-12	1-1000	3251-4500	>845	0-18000	Brownsville, Corpus Christi, Miami, Orlando, West Palm Beach
5.4-13	1-1000	3251-4500	>845	>18000	Loredo, Phoenix, Yuma
5.4-14	1001-1750	0- 500	560-845		Olympia, Portland, Salem, Seattle/Tacoma, Whidbey Island
5.4-15	1001-1750	501-1150	560-845		Asheville, Medford
5.4-16	1001-1750	1-1150	>845		Prescott, Winslow, Yucca
5.4-17	1001-1750	1151-2000	560-845		Charlotte, Chattanooga, Knoxville, Norfolk, Raleigh, Richmond
5.4-18	1001-1750	1151-2000	>845		Albuquerque, Lubbock, Oklahoma City, Roswell, Tucumcari
5.4-19	1001-1750	2001-3250	560-845		Fort Smith, Memphis, Tulsa
5.4-20	1751-2600	0-1150	560-845		Baltimore, Boston, Columbus, Harrisburg, New York, Washington
5.4-21	2601-3200	0-1150	560-845		Akron, Chicago, Detroit, Hartford, Indianapolis, Pittsburgh
5.4-22	1751-3200	0-1150	>845		Boise, Colorado Springs, Denver, Reno, Salt Lake City
5.4-23	1751-3200	1151-2000	560-845		Evansville, Lexington, Louisville, Saint Louis, Springfield
5.4-24	1751-3200	1151-2000	>845		Dodge City, Grand Junction
5.4-25	3201-4000	0-1150	560-845		Albany, Buffalo, Concord, Des Moines, Milwaukee, Rapid City
5.4-26	4001-5000	0-1150	560-845		Bangor, Cutbank, Huron, Minneapolis, Rochester, Sioux Falls
5.4-27	3201-4000	0-1150	>845		Casper, Cheyenne, Ely, North Platte, Scottsbluff
5.4-28	4001-5000	0-1150	>845		Bryce, Eagle, Rock Springs
5.4-29	5001-6500	0-1150	560-845		Bismarck, Duluth, Fargo, Glasgow, International Falls
5.4-30	1-6500	< 100	<560		Adak, Anchorage, Juneau, Kodiak, Yakutat
5.4-31	>6500	< 100	<560		Bethel, Fairbanks, King Salmon, Nome, Summit

ALTERNATE COMPONENT PACKAGES FOR:

HDD50 = 0
CDD65 = 3001 - 4500
VSEW = > 800

Barbers Point HI
Hilo HI
Honolulu HI
Lihue HI

TABLE 5.4-2

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	BASE CASE Uof 1.15 to 0.82	BASE CASE Uof 0.81 to 0	BASE CASE Uof N/A	PERIMETER DAYLIGHTING Uof 1.15 to 0.82	PERIMETER DAYLIGHTING Uof 0.81 to 0	PERIMETER DAYLIGHTING Uof 0.81 to 0 VLT ≥ SC
0 - 1.50	0.000 - 0.249	1.000 - 0.71	17	18		19	19	20
		0.709 - 0.60	21	20		24	24	24
		0.599 - 0.50	25	24		29	28	29
		0.499 - 0.38	31	30		36	34	35
		0.379 - 0.25	41	40		48	46	47
		0.249 - 0.00	67	62		77	72	74
	0.250 - 0.499	1.000 - 0.71	22	21		26	25	26
		0.709 - 0.60	28	27		32	31	32
		0.599 - 0.50	33	32		39	37	39
		0.499 - 0.38	41	39		48	45	47
		0.379 - 0.00	56	52		65	61	63
	0.500 +	1.000 - 0.71	29	28		34	32	33
		0.709 - 0.60	36	35		42	41	42
		0.599 - 0.50	44	42		51	49	50
		0.499 - 0.00	54	51		63	59	61
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	14	13		22	21	23
		0.709 - 0.60	17	17		28	27	29
		0.599 - 0.50	21	20		33	32	34
		0.499 - 0.38	26	24		41	39	41
		0.379 - 0.25	34	33		55	52	55
		0.249 - 0.00	56	52		85	77	84
	0.250 - 0.499	1.000 - 0.71	18	18		29	28	30
		0.709 - 0.60	23	22		37	35	38
		0.599 - 0.50	28	27		45	42	45
		0.499 - 0.38	34	32		55	51	54
		0.379 - 0.00	46	43		73	68	72
	0.500 +	1.000 - 0.71	24	23		38	36	39
		0.709 - 0.60	30	29		49	46	49
		0.599 - 0.50	36	34		59	55	58
		0.499 - 0.00	45	42		71	66	70

OPAQUE WALL Uow

INTERNAL LOAD DENSITY (ILD) RANGE	LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	MASS WALL PCT FEN	MASS WALL INT INS	MASS WALL EXT INS
0 - 1.50	1.00	HC ≥ 5	17	1.00	1.00
		HC ≥ 10	17	1.00	1.00
		HC ≥ 15	17	1.00	1.00
		HC ≥ 5	77	1.00	1.00
		HC ≥ 10	77	1.00	1.00
		HC ≥ 15	77	1.00	1.00
1.51 - 3.00	1.00	HC ≥ 5	14	1.00	1.00
		HC ≥ 10	14	1.00	1.00
		HC ≥ 15	14	1.00	1.00
		HC ≥ 5	85	1.00	1.00
		HC ≥ 10	85	1.00	1.00
		HC ≥ 15	85	1.00	1.00

3.01 - 3.50	0.000 - 0.249	1.000 - 0.71	11	10	20	19	22
		0.709 - 0.60	13	13	25	24	27
		0.599 - 0.50	16	16	30	29	32
		0.499 - 0.38	20	19	37	35	39
		0.379 - 0.25	27	26	51	47	53
		0.249 - 0.00	43	40	76	72	80
	0.250 - 0.499	1.000 - 0.71	14	14	27	26	29
		0.709 - 0.60	18	17	34	32	36
		0.599 - 0.50	22	21	41	39	43
		0.499 - 0.38	26	25	51	47	52
		0.379 - 0.00	36	34	66	63	69
	0.500 -	1.000 - 0.71	18	18	35	33	37
		0.709 - 0.60	23	22	45	42	46
		0.599 - 0.50	28	27	54	50	55
		0.499 - 0.00	35	33	67	61	67

Daylight Sensing Controls

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
1.00	HC ≥ 5	11	1.00	1.00
	HC ≥ 10	11	1.00	1.00
	HC ≥ 15	11	1.00	1.00
	HC ≥ 5	80	1.00	1.00
	HC ≥ 10	80	1.00	1.00
	HC ≥ 15	80	1.00	1.00

	Min R-Value		
WALL BELOW GRADE:	0		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	0	0	0
Vertical	0	0	0

	Max Uo
ROOF:	0.084
WALL ADJACENT TO UNCOND SPACE:	1.00
FLOOR OVER UNCOND SPACE:	1.19

ALTERNATE COMPONENT PACKAGES FOR

HDD50 = 0
CDD65 = > 4500
VSEW = > 845

Guantanamo Bay CU
Kwajalein Island
Koror Island
San Juan PR
Wake Island

TABLE 5 4-3

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	Uof: BASE CASE 1.15 to 0.82	BASE CASE 0.81 to 0	BASE CASE N/A	PERIMETER DAYLIGHTING 1.15 to 0.82	PERIMETER DAYLIGHTING 0.81 to 0	PERIMETER DAYLIGHTING 0.81 to 0 (VLT ≥ SC)
0 - 1.50	0.000 - 0.249	1.000 - 0.71	14	14		17	16	17
		0.709 - 0.60	19	18		21	21	22
		0.599 - 0.50	23	22		26	26	26
		0.499 - 0.38	29	28		33	32	33
		0.379 - 0.25	42	39		49	46	47
		0.249 - 0.00	81	72		96	82	85
	0.250 - 0.499	1.000 - 0.71	20	19		23	22	23
		0.709 - 0.60	26	25		30	29	30
		0.599 - 0.50	32	31		37	35	37
		0.499 - 0.38	41	39		48	45	46
		0.379 - 0.00	62	56		73	66	68
	0.500 +	1.000 - 0.71	27	26		31	30	31
		0.709 - 0.60	35	34		41	39	40
		0.599 - 0.50	45	42		53	49	50
		0.499 - 0.00	59	54		70	63	65
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	12	12		19	19	21
		0.709 - 0.60	18	15		25	24	26
		0.599 - 0.50	19	19		31	30	32
		0.499 - 0.38	24	23		40	38	40
		0.379 - 0.25	35	33		60	54	58
		0.249 - 0.00	66	60		100	93	100
	0.250 - 0.499	1.000 - 0.71	16	16		27	26	28
		0.709 - 0.60	22	21		36	34	36
		0.599 - 0.50	27	26		45	42	45
		0.499 - 0.38	34	32		59	53	57
		0.379 - 0.00	51	47		87	77	82
	0.500 +	1.000 - 6.71	22	22		37	35	38
		0.709 - 0.60	29	28		50	46	49
		0.599 - 0.50	37	35		65	58	61
		0.499 - 0.00	48	46		83	74	78

OPAQUE WALL Uow (LIGHT WEIGHT WALL / MASS WALL)

ILD 0 - 1.50:

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
1.00	HC ≥ 5	14	1.00	1.00
	HC ≥ 10	14	1.00	1.00
	HC ≥ 15	14	1.00	1.00
	HC ≥ 5	85	1.00	1.00
	HC ≥ 10	85	1.00	1.00
	HC ≥ 15	85	1.00	1.00

ILD 1.51 - 3.00:

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
1.00	HC ≥ 5	12	1.00	1.00
	HC ≥ 10	12	1.00	1.00
	HC ≥ 15	12	1.00	1.00
	HC ≥ 5	93	1.00	1.00
	HC ≥ 10	93	1.00	1.00
	HC ≥ 15	93	1.00	1.00

3.01 - 3.50	0.000 - 0.249	1.000 - 0.71	9	9	17	17	19
		0.709 - 0.60	12	12	23	22	25
		0.599 - 0.50	15	14	28	27	31
		0.499 - 0.38	18	18	36	34	38
		0.379 - 0.25	26	25	55	50	55
		0.249 - 0.00	49	46	100	86	96
	0.250 - 0.499	1.000 - 0.71	13	12	24	23	27
		0.709 - 0.60	16	16	32	31	34
		0.599 - 0.50	20	20	41	38	43
		0.499 - 0.38	26	25	54	49	54
		0.379 - 0.00	36	36	80	71	78
	0.500 +	1.000 - 0.71	17	17	34	32	36
		0.709 - 0.60	22	22	46	42	47
		0.599 - 0.50	28	27	60	54	59
		0.499 - 0.00	36	34	77	69	75

Daylight Sensing Controls

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
1.00	HC ≥ 5	9	1.00	1.00
	HC ≥ 10	9	1.00	1.00
	HC ≥ 15	9	1.00	1.00
	HC ≥ 5	86	1.00	1.00
	HC ≥ 10	86	1.00	1.00
	HC ≥ 15	86	1.00	1.00

	Min R-Value				Max Uo
WALL BELOW GRADE:	0			ROOF:	0.057
UNHEATED SLAB ON GRADE:	24"	36"	48"	WALL ADJACENT TO UNCOND SPACE:	1.00
Horizontal	0	0	0		
Vertical	0	0	0	FLOOR OVER UNCOND SPACE:	1.19

ALTERNATE COMPONENT PACKAGES FOR: Arcata CA, North Bend OR

TABLE 5.4-4

HDD50 = 1 - 1000
CDD65 = 0 - 1150
VSEW = 560 - 845

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	Uof BASE CASE 0.81 to 0.46	Uof BASE CASE 0.45 to 0.39	Uof BASE CASE 0.38 to 0	PERIMETER DAYLIGHTING N/A	VLT ≥ SC
0 - 1.50	0.000 - 0.249	1.000 - 0.71	24	32	33		
		0.709 - 0.60	26	37	39		
		0.599 - 0.50	28	41	45		
		0.499 - 0.38	29	46	51		
		0.379 - 0.26	30	52	59		
		0.249 - 0.00	31	59	70		
	0.250 - 0.499	1.000 - 0.71	27	39	42		
		0.709 - 0.60	29	45	49		
		0.599 - 0.50	30	49	55		
		0.499 - 0.38	30	53	61		
		0.379 - 0.00	31	58	68		
	0.500 +	1.000 - 0.71	30	47	52		
		0.709 - 0.60	31	53	59		
		0.599 - 0.50	31	56	64		
		0.499 - 0.00	31	59	69		
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	22	27	28		
		0.709 - 0.60	25	33	34		
		0.599 - 0.50	27	37	39		
		0.499 - 0.38	30	42	45		
		0.379 - 0.26	32	50	55		
		0.249 - 0.00	35	60	69		
	0.250 - 0.499	1.000 - 0.71	27	35	36		
		0.709 - 0.60	29	41	43		
		0.599 - 0.50	31	46	49		
		0.499 - 0.38	33	51	56		
		0.379 - 0.00	35	58	65		
	0.500 +	1.000 - 0.71	30	43	45		
		0.709 - 0.60	32	49	53		
		0.599 - 0.50	34	53	59		
		0.499 - 0.00	35	58	66		

OPAQUE WALL Uow

ILD 0 - 1.50:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.099	HC ≥ 5	24	0.10	0.11
	HC ≥ 10	24	0.12	0.13
	HC ≥ 15	24	0.13	0.14
	HC ≥ 5	70	0.10	0.11
	HC ≥ 10	70	0.11	0.13
	HC ≥ 15	70	0.13	0.14

ILD 1.51 - 3.00:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.099	HC ≥ 5	22	0.10	0.12
	HC ≥ 10	22	0.13	0.16
	HC ≥ 15	22	0.16	0.19
	HC ≥ 5	69	0.10	0.12
	HC ≥ 10	69	0.12	0.16
	HC ≥ 15	69	0.15	0.18

3.01 - 3.50

0.000 - 0.249	1.000 - 0.71	21	25	26
	0.709 - 0.60	24	31	32
	0.599 - 0.50	27	35	37
	0.499 - 0.38	29	40	43
	0.379 - 0.25	32	48	52
	0.249 - 0.00	36	59	67
0.250 - 0.499	1.000 - 0.71	26	33	34
	0.709 - 0.60	28	38	41
	0.599 - 0.50	31	43	46
	0.499 - 0.38	32	49	53
	0.379 - 0.00	35	56	63
0.500 +	1.000 - 0.71	29	40	42
	0.709 - 0.60	32	46	50
	0.599 - 0.50	33	51	56
	0.499 - 0.00	35	56	63

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.099	HC ≥ 5	21	0.10	0.12
	HC ≥ 10	21	0.14	0.18
	HC ≥ 15	21	0.18	0.21
	HC ≥ 5	67	0.10	0.12
	HC ≥ 10	67	0.13	0.17
	HC ≥ 15	67	0.16	0.19

Daylight Sensing Controls

	Min R-Value		
WALL BELOW GRADE:	8		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	15	13	10
Vertical	7	6	4

	Max Uo
ROOF:	0.070
WALL ADJACENT TO UNCOND SPACE:	0.15
FLOOR OVER UNCOND SPACE:	0.062

ALTERNATE COMPONENT PACKAGES FOR:

HDD50 = 1 - 1000
CDD65 = 0 - 300
VSEW = > 845

Oakland CA
Point Magu CA
San Francisco CA
Santa Maria CA
Sunnyville CA

TABLE 5.4-6

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	BASE CASE Uof 1.15 to 0.82	BASE CASE Uof 0.81 to 0	BASE CASE Uof N/A	PERIMETER DAYLIGHTING Uof 1.15 to 0.82	PERIMETER DAYLIGHTING Uof 0.81 to 0	PERIMETER DAYLIGHTING Uof 0.45 to 0 (VLT ≥ SC)
0 - 1.50	0.000 - 0.249	1.000 - 0.71	24	26		26	28	29
		0.709 - 0.60	29	31		32	34	36
		0.599 - 0.50	34	36		36	39	43
		0.499 - 0.38	39	43		41	46	51
		0.379 - 0.25	47	54		49	57	66
		0.249 - 0.00	60	72		61	75	96
	0.250 - 0.499	1.000 - 0.71	31	33		33	36	39
		0.709 - 0.60	37	40		39	43	48
		0.599 - 0.50	42	46		44	50	56
		0.499 - 0.38	47	54		50	57	67
		0.379 - 0.00	56	66		58	69	85
	0.500 +	1.000 - 0.71	38	42		41	45	50
		0.709 - 0.60	45	50		47	54	61
		0.599 - 0.50	50	57		52	61	71
		0.499 - 0.00	55	65		57	69	84
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	19	20		26	27	28
		0.709 - 0.60	24	25		31	33	35
		0.599 - 0.50	28	29		35	38	41
		0.499 - 0.38	32	34		40	45	49
		0.379 - 0.25	40	44		49	56	64
		0.249 - 0.00	54	62		61	74	93
	0.250 - 0.499	1.000 - 0.71	25	26		32	35	37
		0.709 - 0.60	31	32		38	42	46
		0.599 - 0.50	35	38		43	48	54
		0.499 - 0.38	41	44		49	56	65
		0.379 - 0.00	49	56		57	68	83
	0.500 +	1.000 - 0.71	32	33		40	44	48
		0.709 - 0.60	38	41		46	52	59
		0.599 - 0.50	43	47		51	59	70
		0.499 - 0.00	49	55		57	67	82

OPAQUE WALL Uow

ILD 0 - 1.50:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.15	HC ≥ 5	24	0.21	0.37
	HC ≥ 10	24	0.36	0.50
	HC ≥ 15	24	0.47	0.58
	HC ≥ 5	85	0.21	0.37
	HC ≥ 10	85	0.35	0.49
	HC ≥ 15	85	0.45	0.56

ILD 1.51 - 3.00:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.15	HC ≥ 5	19	0.28	0.49
	HC ≥ 10	19	0.48	0.72
	HC ≥ 15	19	0.67	0.80
	HC ≥ 5	93	0.20	0.38
	HC ≥ 10	93	0.38	0.53
	HC ≥ 15	93	0.49	0.61

3.01 - 3.50

0.000 - 0.249	1.000 - 0.71	17	17	25	26	27
	0.709 - 0.60	21	21	30	32	34
	0.599 - 0.50	24	25	34	37	40
	0.499 - 0.38	29	30	39	43	48
	0.379 - 0.25	36	39	47	54	63
	0.249 - 0.00	49	56	60	72	90
0.250 - 0.499	1.000 - 0.71	22	23	31	34	36
	0.709 - 0.60	27	28	37	41	45
	0.599 - 0.50	31	33	42	47	53
	0.499 - 0.38	36	39	47	54	63
	0.379 - 0.00	45	50	56	66	81
0.500 +	1.000 - 0.71	28	29	38	42	47
	0.709 - 0.60	34	36	45	50	58
	0.599 - 0.50	38	42	50	57	68
	0.499 - 0.00	44	49	55	65	79

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.15	HC ≥ 5	17	0.32	0.53
	HC ≥ 10	17	0.53	0.80
	HC ≥ 15	17	0.74	0.80
	HC ≥ 5	90	0.22	0.39
	HC ≥ 10	90	0.39	0.56
	HC ≥ 15	90	0.52	0.65

Daylight Sensing Controls

	Min R-Value		
WALL BELOW GRADE:	7		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	11	9	7
Vertical	6	5	4

	Max Uo
ROOF:	0.089
WALL ADJACENT TO UNCOND SPACE:	0.21
FLOOR OVER UNCOND SPACE:	0.094

ALTERNATE COMPONENT PACKAGES FOR:

HDD50 = 1 - 1000
CDD65 = 301 - 1150
VSEW = > 846

El Toro CA
Long Beach CA
Los Angeles CA
San Diego CA

TABLE 5.4-6

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	BASE CASE Uof 1.15 to 0.82	BASE CASE Uof 0.81 to 0	BASE CASE Uof N/A	PERIMETER DAYLIGHTING Uof 1.15 to 0.82	PERIMETER DAYLIGHTING Uof 0.81 to 0	PERIMETER DAYLIGHTING VLT ≥ SC Uof 0.81 to 0
0 - 1.50	0.000 - 0.249	1.000 - 0.71	18	18		21	21	21
		0.709 - 0.60	23	23		26	26	26
		0.599 - 0.50	27	27		30	31	31
		0.499 - 0.38	33	33		36	37	38
		0.379 - 0.25	43	44		47	49	50
		0.249 - 0.00	64	67		70	73	75
	0.250 - 0.499	1.000 - 0.71	24	24		27	27	28
		0.709 - 0.60	30	30		34	34	35
		0.599 - 0.50	36	36		40	40	41
		0.499 - 0.38	43	43		47	49	50
		0.379 - 0.00	56	57		61	64	65
	0.500 +	1.000 - 0.71	31	32		35	35	36
		0.709 - 0.60	39	39		43	44	45
		0.599 - 0.50	46	47		51	52	53
		0.499 - 0.00	55	56		60	62	64
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	14	14		21	21	22
		0.709 - 0.60	18	18		26	26	27
		0.599 - 0.50	21	21		31	31	33
		0.499 - 0.38	26	26		37	37	39
		0.379 - 0.25	35	34		49	49	52
		0.249 - 0.00	54	54		72	74	78
	0.250 - 0.499	1.000 - 0.71	19	19		27	27	29
		0.709 - 0.60	24	24		34	34	36
		0.599 - 0.50	28	28		41	41	43
		0.499 - 0.38	34	34		49	49	52
		0.379 - 0.00	46	46		64	65	69
	0.500 +	1.000 - 0.71	25	25		36	36	38
		0.709 - 0.60	31	31		44	44	47
		0.599 - 0.50	37	37		52	53	56
		0.499 - 0.00	45	44		63	64	67

OPAQUE WALL Uow

ILD RANGE	LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0 - 1.50	0.23	HC ≥ 5	18	0.58	0.80
		HC ≥ 10	18	0.80	0.80
		HC ≥ 15	18	0.80	0.80
		HC ≥ 5	75	0.46	0.80
		HC ≥ 10	75	0.80	0.80
		HC ≥ 15	75	0.80	0.80
1.51 - 3.00	0.23	HC ≥ 5	14	0.80	0.80
		HC ≥ 10	14	0.80	0.80
		HC ≥ 15	14	0.80	0.80
		HC ≥ 5	78	0.66	0.80
		HC ≥ 10	78	0.80	0.80
		HC ≥ 15	78	0.80	0.80

3.01 - 3.50

0.000 - 0.249	1.000 - 0.71	12	12	19	19	21
	0.709 - 0.60	15	15	24	24	26
	0.599 - 0.50	18	17	29	29	31
	0.499 - 0.38	21	21	35	35	38
	0.379 - 0.25	29	28	46	46	50
	0.249 - 0.00	45	44	69	70	75
0.250 - 0.499	1.000 - 0.71	16	15	26	25	28
	0.709 - 0.60	20	19	32	32	35
	0.599 - 0.50	23	23	38	38	42
	0.499 - 0.38	28	28	46	46	50
	0.379 - 0.00	38	38	60	61	66
0.500 +	1.000 - 0.71	20	20	33	33	36
	0.709 - 0.60	26	25	41	42	45
	0.599 - 0.50	30	30	49	49	54
	0.499 - 0.00	37	37	59	60	65

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.23	HC ≥ 5	12	0.80	0.80
	HC ≥ 10	12	0.80	0.80
	HC ≥ 15	12	0.80	0.80
	HC ≥ 5	75	0.72	0.80
	HC ≥ 10	75	0.80	0.80
	HC ≥ 15	75	0.80	0.80

Daylight Sensing Controls

	Min R-Value		
WALL BELOW GRADE:	0		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	0	0	0
Vertical	0	0	0

	Max Uo
ROOF:	0.10
WALL ADJACENT TO UNCOND SPACE:	0.30
FLOOR OVER UNCOND SPACE:	0.10

ALTERNATE COMPONENT PACKAGES FOR.

HDD50 = 1 - 1000
CDD65 = 1151 - 2000
VSEW = 500 - 845

Atlanta GA
Birmingham AL
Cape Hatteras NC
Cherry Point NC
Greenville SC

TABLE 5.4-7

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	BASE CASE Uof 1.15 to 0.82	BASE CASE Uof 0.81 to 0	BASE CASE Uof N/A	PERIMETER DAYLIGHTING Uof 1.15 to 0.82	PERIMETER DAYLIGHTING Uof 0.81 to 0	PERIMETER DAYLIGHTING Uof 0.81 to 0 (VLT ≥ SC)
0 - 1.50	0.000 - 0.249	1.000 - 0.71	19	20		21	22	23
		0.709 - 0.60	24	25		26	27	28
		0.599 - 0.50	28	29		30	32	33
		0.499 - 0.38	32	35		35	38	39
		0.379 - 0.25	41	45		44	49	50
		0.249 - 0.00	50	64		59	69	70
	0.250 - 0.499	1.000 - 0.71	25	26		28	29	30
		0.709 - 0.60	30	32		33	36	36
		0.599 - 0.50	35	38		38	42	42
		0.499 - 0.38	41	45		44	49	50
		0.379 - 0.00	50	57		54	61	63
	0.500 +	1.000 - 0.71	31	33		34	37	38
		0.709 - 0.60	38	41		41	45	46
		0.599 - 0.50	43	47		47	52	53
		0.499 - 0.00	49	56		53	60	62
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	15	15		21	21	23
		0.709 - 0.60	19	19		25	27	28
		0.599 - 0.50	22	22		30	31	33
		0.499 - 0.38	26	27		35	37	39
		0.379 - 0.25	33	35		43	48	51
		0.249 - 0.00	47	52		59	68	71
	0.250 - 0.499	1.000 - 0.71	20	20		27	28	30
		0.709 - 0.60	24	26		33	35	37
		0.599 - 0.50	28	29		38	40	43
		0.499 - 0.38	33	35		43	48	50
		0.379 - 0.00	42	46		53	61	64
	0.500 +	1.000 - 0.71	26	26		34	36	38
		0.709 - 0.60	30	32		40	44	46
		0.599 - 0.50	35	37		46	51	54
		0.499 - 0.00	41	44		52	59	63

OPAQUE WALL Uow

ILD 0 - 1.50:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.16	HC ≥ 5	19	0.21	0.30
	HC ≥ 10	19	0.31	0.39
	HC ≥ 15	19	0.40	0.42
	HC ≥ 5	70	0.20	0.27
	HC ≥ 10	70	0.27	0.36
	HC ≥ 15	70	0.36	0.39

ILD 1.51 - 3.00:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.16	HC ≥ 5	15	0.22	0.34
	HC ≥ 10	15	0.36	0.43
	HC ≥ 15	15	0.45	0.47
	HC ≥ 5	71	0.20	0.29
	HC ≥ 10	71	0.29	0.38
	HC ≥ 15	71	0.39	0.40

3.01 - 3.50

0.000 - 0.249	1.000 - 0.71	13	13	20	20	22
	0.709 - 0.60	16	16	24	25	27
	0.599 - 0.50	18	19	28	29	32
	0.499 - 0.38	22	23	33	35	38
	0.379 - 0.25	28	30	41	45	49
	0.249 - 0.00	41	45	55	64	69
0.250 - 0.499	1.000 - 0.71	16	17	25	27	29
	0.709 - 0.60	20	21	31	33	35
	0.599 - 0.50	24	25	35	38	41
	0.499 - 0.38	28	30	41	45	49
	0.379 - 0.00	36	39	50	57	62
0.500 +	1.000 - 0.71	21	22	32	34	36
	0.709 - 0.60	26	27	38	41	45
	0.599 - 0.50	30	32	43	48	52
	0.499 - 0.00	35	38	49	56	61

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.16	HC ≥ 5	13	0.22	0.34
	HC ≥ 10	13	0.36	0.43
	HC ≥ 15	13	0.46	0.48
	HC ≥ 5	69	0.20	0.29
	HC ≥ 10	69	0.30	0.39
	HC ≥ 15	69	0.40	0.41

Daylight Sensing Controls

	Min R-Value		
WALL BELOW GRADE:	7		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	11	9	7
Vertical	6	5	4

	Max Uo
ROOF:	0.069
WALL ADJACENT TO UNCOND SPACE:	0.21
FLOOR OVER UNCOND SPACE:	0.095

ALTERNATE COMPONENT PACKAGES FOR:

Fresno CA
Redbluff CA
Sacramento CA

TABLE 5.4-8

HDD50 = 1 - 1000
CDD65 = 1151 - 2000
VSEW = > 845

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	Uof: BASE CASE 1.15 to 0.82	BASE CASE 0.81 to 0	BASE CASE N/A	PERIMETER DAYLIGHTING 1.15 to 0.82	PERIMETER DAYLIGHTING 0.81 to 0	PERIMETER DAYLIGHTING VLT ≥ SC 0.81 to 0
0 - 1.50	0.000 - 0.249	1.000 - 0.71	19	20		21	22	22
		0.709 - 0.60	24	25		26	27	28
		0.599 - 0.50	28	29		30	32	33
		0.499 - 0.38	33	35		35	38	39
		0.379 - 0.26	41	45		44	49	50
		0.249 - 0.00	56	65		59	69	70
	0.250 - 0.499	1.000 - 0.71	25	26		27	29	29
		0.709 - 0.60	31	33		33	36	36
		0.599 - 0.50	36	38		38	42	42
		0.499 - 0.38	41	45		44	49	50
		0.379 - 0.00	51	58		53	62	63
	0.500 +	1.000 - 0.71	32	34		34	37	38
		0.709 - 0.60	38	42		41	45	46
		0.599 - 0.50	44	48		47	52	53
		0.499 - 0.00	50	57		53	61	62
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	15	15		20	21	22
		0.709 - 0.60	18	19		25	26	27
		0.599 - 0.50	22	23		29	30	32
		0.499 - 0.38	26	27		34	36	38
		0.379 - 0.26	33	36		42	47	49
		0.249 - 0.00	47	53		58	67	70
	0.250 - 0.499	1.000 - 0.71	20	20		26	28	29
		0.709 - 0.60	24	25		32	34	36
		0.599 - 0.50	28	30		37	40	42
		0.499 - 0.38	33	35		43	47	50
		0.379 - 0.00	42	46		52	60	63
	0.500 +	1.000 - 0.71	25	26		33	35	37
		0.709 - 0.60	31	32		40	43	45
		0.599 - 0.50	35	38		45	50	53
		0.499 - 0.00	41	45		52	59	62

OPAQUE WALL Uow

ILD 0 - 1.50:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.15	HC ≥ 5	19	0.20	0.33
	HC ≥ 10	19	0.34	0.44
	HC ≥ 15	19	0.44	0.49
	HC ≥ 5	70	0.19	0.30
	HC ≥ 10	70	0.29	0.40
	HC ≥ 15	70	0.40	0.44

ILD 1.51 - 3.00:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.15	HC ≥ 5	15	0.21	0.36
	HC ≥ 10	15	0.37	0.48
	HC ≥ 15	15	0.48	0.53
	HC ≥ 5	70	0.20	0.32
	HC ≥ 10	70	0.32	0.42
	HC ≥ 15	70	0.43	0.47

3.01 - 3.50

0.000 - 0.249	1.000 - 0.71	13	13	19	20	21
	0.709 - 0.60	16	16	23	24	26
	0.599 - 0.50	19	19	27	29	31
	0.499 - 0.38	22	23	32	34	37
	0.379 - 0.25	29	31	40	44	48
	0.249 - 0.00	42	46	55	64	68
0.250 - 0.499	1.000 - 0.71	17	17	25	26	28
	0.709 - 0.60	21	21	30	32	35
	0.599 - 0.50	24	25	35	38	40
	0.499 - 0.38	29	30	40	44	48
	0.379 - 0.00	37	40	50	57	61
0.500 +	1.000 - 0.71	22	22	31	33	36
	0.709 - 0.60	26	28	37	41	44
	0.599 - 0.50	31	33	43	48	51
	0.499 - 0.00	36	39	49	56	60

Daylight Sensing Controls

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.15	HC ≥ 5	13	0.21	0.37
	HC ≥ 10	13	0.38	0.48
	HC ≥ 15	13	0.49	0.54
	HC ≥ 5	60	0.20	0.32
	HC ≥ 10	60	0.32	0.43
	HC ≥ 15	60	0.43	0.48

	Min R-Value		
WALL BELOW GRADE:	0		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	0	0	0
Vertical	0	0	0

	Max Uo
ROOF:	0.060
WALL ADJACENT TO UNCOND SPACE:	0.23
FLOOR OVER UNCOND SPACE:	0.10

ALTERNATE COMPONENT PACKAGES FOR:

HDD50 = 1 - 1000
CDD65 = 2000 - 3250
VSEW = 560 - 845

Baton Rouge LA
Charleston SC
Columbia SC
Houston TX
Jackson MS
Lake Charles LA
Little Rock AR
Macon GA
Meridian MS
Mobile AL
Montgomery AL
New Orleans LA
Port Angeles TX
Savannah GA
Shreveport LA

TABLE 5.4-9

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	Uof: BASE CASE 1.15 to 0.82	BASE CASE 0.81 to 0	BASE CASE N/A	PERIMETER DAYLIGHTING 1.15 to 0.82	PERIMETER DAYLIGHTING 0.81 to 0	PERIMETER DAYLIGHTING VLT ≥ SC 0.81 to 0
0 - 1.50	0.000 - 0.249	1.000 - 0.71	19	19		21	22	22
		0.709 - 0.60	23	24		26	27	27
		0.599 - 0.50	27	28		30	32	32
		0.499 - 0.38	32	34		36	38	38
		0.379 - 0.25	41	44		45	49	50
		0.249 - 0.00	59	66		63	72	73
	0.250 - 0.499	1.000 - 0.71	24	25		27	28	29
		0.709 - 0.60	30	31		33	35	36
		0.599 - 0.50	35	37		39	41	42
		0.499 - 0.38	41	44		45	49	50
		0.379 - 0.00	52	57		57	63	64
	0.500 +	1.000 - 0.71	31	32		34	36	37
		0.709 - 0.60	38	40		42	46	46
		0.599 - 0.50	44	47		48	52	53
		0.499 - 0.00	51	56		56	62	63
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	15	15		21	21	23
		0.709 - 0.60	18	18		26	27	28
		0.599 - 0.50	22	22		30	31	33
		0.499 - 0.38	26	27		36	38	40
		0.379 - 0.25	34	35		46	49	52
		0.249 - 0.00	49	53		65	72	76
	0.250 - 0.499	1.000 - 0.71	19	20		27	28	30
		0.709 - 0.60	24	24		33	36	37
		0.599 - 0.50	28	29		39	41	44
		0.499 - 0.38	33	36		46	49	52
		0.379 - 0.00	43	46		58	64	67
	0.500 +	1.000 - 0.71	25	25		35	36	38
		0.709 - 0.60	30	31		42	45	47
		0.599 - 0.50	35	37		49	53	56
		0.499 - 0.00	42	45		57	62	66

OPAQUE WALL Uow

ILD 0 - 1.50:

LIGHT WEIGHT WALL: Uow (HC<5)	MASS WALL: HC RANGE	PCT FEN	INT INS	EXT INS
0.18	HC ≥ 5	19	0.23	0.35
	HC ≥ 10	19	0.36	0.43
	HC ≥ 15	19	0.45	0.47
	HC ≥ 5	73	0.22	0.32
	HC ≥ 10	73	0.33	0.40
	HC ≥ 15	73	0.42	0.44

ILD 1.51 - 3.00:

LIGHT WEIGHT WALL: Uow (HC<5)	MASS WALL: HC RANGE	PCT FEN	INT INS	EXT INS
0.18	HC ≥ 5	15	0.24	0.37
	HC ≥ 10	15	0.39	0.47
	HC ≥ 15	15	0.49	0.52
	HC ≥ 5	76	0.24	0.36
	HC ≥ 10	76	0.36	0.44
	HC ≥ 15	76	0.46	0.48

3.01 - 3.50

0.000 - 0.249	1.000 - 0.71	12	12	19	20	22
	0.709 - 0.60	15	15	24	25	27
	0.599 - 0.50	18	18	28	29	32
	0.499 - 0.38	22	22	33	35	38
	0.379 - 0.25	28	29	43	46	50
	0.249 - 0.00	42	45	61	68	73
0.250 - 0.499	1.000 - 0.71	16	16	26	26	29
	0.709 - 0.60	20	20	31	33	36
	0.599 - 0.50	23	24	36	39	42
	0.499 - 0.38	28	29	43	46	50
	0.379 - 0.00	36	38	54	60	65
0.500 +	1.000 - 0.71	21	21	32	34	37
	0.709 - 0.60	25	26	39	42	45
	0.599 - 0.50	30	31	46	49	53
	0.499 - 0.00	35	37	53	59	64

Daylight Sensing Controls

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.18	HC ≥ 5	12	0.24	0.37
	HC ≥ 10	12	0.39	0.47
	HC ≥ 15	12	0.49	0.53
	HC ≥ 5	73	0.23	0.35
	HC ≥ 10	73	0.36	0.43
	HC ≥ 15	73	0.45	0.48

	Min R-Value		
WALL BELOW GRADE:	7		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	10	9	7
Vertical	6	5	4

	Max Uo
ROOF:	0.064
WALL ADJACENT TO UNCOND SPACE:	0.22
FLOOR OVER UNCOND SPACE:	0.098

ALTERNATE COMPONENT PACKAGES FOR:

HDD50 = 1 - 1000
CDD65 = 2001 - 3250
VSEW =) 845

Abilene TX, Apalachicola FL, Austin TX, Bakersfield CA, Daytona Beach FL, Del Rio TX, El Paso TX, Fort Worth TX, Jacksonville FL, San Antonio TX, Sherman TX, Tallahassee FL, Tampa FL, Waco TX, Wichita Falls TX

TABLE 6.4-10

Uof

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	BASE CASE 1.15 to 0.82	BASE CASE 0.81 to 0	BASE CASE N/A	PERIMETER DAYLIGHTING 1.15 to 0.82	PERIMETER DAYLIGHTING 0.81 to 0	PERIMETER DAYLIGHTING VLT ≥ SC 0.81 to 0
0 - 1.50	0.000 - 0.249	1.000 - 0.71	19	19		21	21	22
		0.709 - 0.60	23	24		25	27	27
		0.599 - 0.50	27	28		29	31	32
		0.499 - 0.38	32	34		34	37	38
		0.379 - 0.25	40	44		43	48	49
		0.249 - 0.00	55	64		59	69	70
	0.250 - 0.499	1.000 - 0.71	24	26		27	28	29
		0.709 - 0.60	30	32		32	35	36
		0.599 - 0.50	34	37		37	41	41
		0.499 - 0.38	40	44		43	48	49
		0.379 - 0.00	50	56		53	61	62
	0.500 +	1.000 - 0.71	31	33		34	36	37
		0.709 - 0.60	37	40		40	44	45
		0.599 - 0.50	42	47		46	51	52
		0.499 - 0.00	49	55		52	60	61
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	15	16		20	21	22
		0.709 - 0.60	18	19		25	26	27
		0.599 - 0.50	21	22		29	31	32
		0.499 - 0.38	25	27		34	37	39
		0.379 - 0.26	33	36		43	48	50
		0.249 - 0.00	47	53		59	68	72
	0.250 - 0.499	1.000 - 0.71	19	20		26	28	29
		0.709 - 0.60	24	25		32	34	36
		0.599 - 0.50	28	29		37	40	42
		0.499 - 0.38	33	35		43	48	50
		0.379 - 0.00	41	46		53	61	64
	0.500 +	1.000 - 0.71	24	26		33	35	37
		0.709 - 0.60	30	32		40	43	46
		0.599 - 0.50	35	37		46	51	53
		0.499 - 0.00	41	44		52	60	63

OPAQUE WALL Uow (LIGHT WEIGHT WALL; MASS WALL)

ILD 0 - 1.50:

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.15	HC ≥ 5	19	0.17	0.26
	HC ≥ 10	19	0.22	0.32
	HC ≥ 15	19	0.29	0.36
	HC ≥ 5	70	0.17	0.23
	HC ≥ 10	70	0.21	0.30
	HC ≥ 15	70	0.27	0.32

ILD 1.51 - 3.00:

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.15	HC ≥ 5	16	0.17	0.26
	HC ≥ 10	16	0.23	0.35
	HC ≥ 15	16	0.32	0.38
	HC ≥ 5	72	0.17	0.24
	HC ≥ 10	72	0.22	0.32
	HC ≥ 15	72	0.29	0.35

3.01 - 3.50

0.000 - 0.249	1.000 - 0.71	12	13	19	20	21
	0.709 - 0.60	15	16	23	24	26
	0.599 - 0.50	18	19	27	29	31
	0.499 - 0.38	22	23	32	34	37
	0.379 - 0.25	28	30	40	45	48
	0.249 - 0.00	41	45	56	65	70
0.250 - 0.499	1.000 - 0.71	16	17	25	26	28
	0.709 - 0.60	20	21	30	32	35
	0.599 - 0.50	24	25	35	38	41
	0.499 - 0.38	28	30	40	45	48
	0.379 - 0.00	36	39	50	57	62
0.500 +	1.000 - 0.71	21	22	31	33	36
	0.709 - 0.60	26	27	37	41	44
	0.599 - 0.50	30	32	43	48	52
	0.499 - 0.00	35	38	49	56	61

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.15	HC ≥ 5	12	0.17	0.26
	HC ≥ 10	12	0.23	0.35
	HC ≥ 15	12	0.32	0.38
	HC ≥ 5	70	0.17	0.24
	HC ≥ 10	70	0.22	0.32
	HC ≥ 15	70	0.29	0.35

Daylight Sensing Controls

	Min R-Value		
WALL BELOW GRADE:	7		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	10	9	7
Vertical	6	5	4

	Max Uo
ROOF:	0.057
WALL ADJACENT TO UNCOND SPACE:	0.22
FLOOR OVER UNCOND SPACE:	0.100

ALTERNATE COMPONENT PACKAGES FOR:

HDD65 = 1 - 1000
CDD65 = 2001 - 3250
VSEW = > 845
CDH80 = > 10000

China Lake CA
Daggett CA
Las Vegas CA
Tuscon AZ

TABLE 6.4-11

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	Uof: BASE CASE 1.15 to 0.82	BASE CASE 0.81 to 0	BASE CASE N/A	PERIMETER DAYLIGHTING 1.15 to 0.82	PERIMETER DAYLIGHTING 0.81 to 0	PERIMETER DAYLIGHTING 0.81 to 0 (VLT ≥ SC)
0 - 1.50	0.000 - 0.249	1.000 - 0.71	17	17		18	19	19
		0.709 - 0.60	21	22		23	23	24
		0.599 - 0.50	25	26		27	28	29
		0.499 - 0.38	30	31		32	34	35
		0.379 - 0.25	39	42		42	45	46
		0.249 - 0.00	59	65		63	70	71
	0.250 - 0.499	1.000 - 0.71	22	23		24	25	26
		0.709 - 0.60	28	29		30	31	32
		0.599 - 0.50	33	34		36	37	38
		0.499 - 0.38	39	42		42	45	48
		0.379 - 0.00	51	56		65	60	61
	0.500 +	1.000 - 0.71	29	30		31	33	33
		0.709 - 0.60	36	38		39	41	42
		0.599 - 0.50	42	46		45	49	50
		0.499 - 0.00	50	54		54	59	60
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	14	14		18	19	20
		0.709 - 0.60	17	17		23	23	25
		0.599 - 0.50	20	21		27	28	30
		0.499 - 0.38	25	25		33	34	36
		0.379 - 0.25	33	34		43	45	48
		0.249 - 0.00	50	54		65	71	75
	0.250 - 0.499	1.000 - 0.71	18	18		24	25	26
		0.709 - 0.60	23	23		30	31	33
		0.599 - 0.50	27	28		36	37	40
		0.499 - 0.38	33	34		43	46	48
		0.379 - 0.00	43	46		56	61	65
	0.500 +	1.000 - 0.71	24	24		32	33	35
		0.709 - 0.60	29	31		39	41	43
		0.599 - 0.50	36	37		46	49	52
		0.499 - 0.00	42	45		55	60	63

OPAQUE WALL Uow

ILD 0 - 1.50:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.17	HC ≥ 5	17	0.19	0.24
	HC ≥ 10	17	0.24	0.31
	HC ≥ 15	17	0.29	0.33
	HC ≥ 5	71	0.19	0.24
	HC ≥ 10	71	0.24	0.31
	HC ≥ 15	71	0.29	0.33

ILD 1.51 - 3.00:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.17	HC ≥ 5	14	0.19	0.26
	HC ≥ 10	14	0.24	0.31
	HC ≥ 15	14	0.30	0.34
	HC ≥ 5	75	0.19	0.26
	HC ≥ 10	75	0.24	0.31
	HC ≥ 15	75	0.30	0.34

3.01 - 3.50

0.000 - 0.249	1.000 - 0.71	12	12	17	17	19
	0.709 - 0.60	16	15	21	22	24
	0.599 - 0.50	17	18	25	26	28
	0.499 - 0.38	21	22	31	32	35
	0.379 - 0.25	28	29	40	43	46
	0.249 - 0.00	44	46	61	67	72
0.250 - 0.499	1.000 - 0.71	15	16	23	23	25
	0.709 - 0.60	20	20	28	29	32
	0.599 - 0.50	23	24	34	35	38
	0.499 - 0.38	28	29	40	43	46
	0.379 - 0.00	37	39	53	58	62
0.500 +	1.000 - 0.71	20	21	30	31	33
	0.709 - 0.60	25	26	37	39	42
	0.599 - 0.50	30	31	44	46	50
	0.499 - 0.00	36	38	52	56	61

Daylight Sensing Controls

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.17	HC ≥ 5	12	0.19	0.25
	HC ≥ 10	12	0.24	0.31
	HC ≥ 15	12	0.30	0.34
	HC ≥ 5	72	0.19	0.26
	HC ≥ 10	72	0.25	0.32
	HC ≥ 15	72	0.31	0.36

	Min R-Value		
WALL BELOW GRADE:	0		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	0	0	0
Vertical	0	0	0

	Max Uo
ROOF:	0.049
WALL ADJACENT TO UNCOND SPACE:	0.25
FLOOR OVER UNCOND SPACE:	0.12

ALTERNATE COMPONENT PACKAGES FOR:

HDD50 = 1 - 1000
CDD65 = 3251 - 4500
VSEW = > 045
CDH80 = 0 - 18000

Brownsville TX
Corpus Christi TX
Kingsville TX
Miami FL
Orlando FL

West Palm Beach FL

TABLE 5.4-12

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	Uof: BASE CASE 1.15 to 0.82	BASE CASE 0.81 to 0	BASE CASE N/A	PERIMETER DAYLIGHTING 1.15 to 0.82	PERIMETER DAYLIGHTING 0.81 to 0	PERIMETER DAYLIGHTING 0.81 to 0 (VLT ≥ SC)
0 - 1.50	0.000 - 0.249	1.000 - 0.71	15	15		18	17	18
		0.709 - 0.60	20	19		22	22	23
		0.599 - 0.50	24	23		27	27	28
		0.499 - 0.38	29	29		34	33	34
		0.379 - 0.25	41	40		48	46	48
		0.249 - 0.00	74	70		86	80	83
	0.250 - 0.499	1.000 - 0.71	21	20		24	24	24
		0.709 - 0.60	27	26		31	30	31
		0.599 - 0.50	33	32		38	37	38
		0.499 - 0.38	41	40		48	46	47
		0.379 - 0.00	59	57		69	66	67
	0.500 +	1.000 - 0.71	28	27		32	31	32
		0.709 - 0.60	36	35		42	41	42
		0.599 - 0.50	44	43		52	50	51
		0.499 - 0.00	57	54		67	63	65
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	13	12		19	19	21
		0.709 - 0.60	16	16		25	24	26
		0.599 - 0.50	20	19		31	30	32
		0.499 - 0.38	24	24		38	37	40
		0.379 - 0.25	34	33		55	52	56
		0.249 - 0.00	61	58		97	88	95
	0.250 - 0.499	1.000 - 0.71	17	17		27	26	28
		0.709 - 0.60	22	22		35	34	36
		0.599 - 0.50	27	26		43	41	44
		0.499 - 0.38	34	33		55	52	55
		0.379 - 0.00	49	47		79	73	78
	0.500 +	1.000 - 0.71	23	22		36	35	37
		0.709 - 0.60	30	29		48	46	49
		0.599 - 0.50	37	36		60	57	60
		0.499 - 0.00	47	45		76	71	76

OPAQUE WALL Uow

ILD 0 - 1.50:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.49	HC ≥ 5	15	0.61	0.76
	HC ≥ 10	15	0.80	0.80
	HC ≥ 15	15	0.80	0.80
	HC ≥ 5	86	0.65	0.80
	HC ≥ 10	86	0.80	0.80
	HC ≥ 15	86	0.80	0.80

ILD 1.51 - 3.00:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.49	HC ≥ 5	13	0.61	0.78
	HC ≥ 10	13	0.80	0.80
	HC ≥ 15	13	0.80	0.80
	HC ≥ 5	88	0.67	0.80
	HC ≥ 10	88	0.80	0.80
	HC ≥ 15	88	0.80	0.80

3.01 - 3.50

0.000 - 0.249	1.000 - 0.71	10	10	18	17	20
	0.709 - 0.60	13	13	23	22	25
	0.599 - 0.50	16	15	28	27	31
	0.499 - 0.38	19	19	35	34	38
	0.379 - 0.25	27	26	51	48	53
	0.249 - 0.00	48	45	89	81	90
0.250 - 0.499	1.000 - 0.71	14	13	24	24	27
	0.709 - 0.60	17	17	32	31	34
	0.599 - 0.50	21	21	40	38	42
	0.499 - 0.38	27	26	51	48	53
	0.379 - 0.00	38	37	73	69	75
0.500 +	1.000 - 0.71	18	18	33	32	36
	0.709 - 0.60	23	23	44	42	46
	0.599 - 0.50	29	28	56	52	57
	0.499 - 0.00	36	35	71	67	72

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.49	HC ≥ 5	10	0.61	0.76
	HC ≥ 10	10	0.80	0.80
	HC ≥ 15	10	0.80	0.80
	HC ≥ 5	90	0.67	0.80
	HC ≥ 10	90	0.80	0.80
	HC ≥ 15	90	0.80	0.80

Daylight Sensing Controls

	Min R-Value		
WALL BELOW GRADE:	0		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	0	0	0
Vertical	0	0	0

	Max Uo
ROOF:	0.064
WALL ADJACENT TO UNCOND SPACE:	0.63
FLOOR OVER UNCOND SPACE:	0.28

ALTERNATE COMPONENT PACKAGES FOR: Laredo TX, Phoenix AZ, Yuma AZ — TABLE 5.4-13

HDD50 = 1 - 1000
CDD65 = 3250 - 4500
VSEW = > 845
CDH80 = > 18000

Uof

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	BASE CASE 1.15 to 0.82	BASE CASE 0.81 to 0	BASE CASE N/A	PERIMETER DAYLIGHTING 1.15 to 0.82	PERIMETER DAYLIGHTING 0.81 to 0	PERIMETER DAYLIGHTING 0.81 to 0 (VLT ≥ SC)
0 - 1.50	0.000 - 0.249	1.000 - 0.71	15	15		17	17	17
		0.709 - 0.60	19	19		22	21	22
		0.599 - 0.50	23	23		27	26	27
		0.499 - 0.38	29	28		33	33	34
		0.379 - 0.25	41	40		47	46	48
		0.249 - 0.00	75	72		88	83	85
	0.250 - 0.499	1.000 - 0.71	20	20		23	23	24
		0.709 - 0.60	26	26		30	30	30
		0.599 - 0.50	32	31		37	36	37
		0.499 - 0.38	40	40		47	46	47
		0.379 - 0.00	59	57		69	66	68
	0.500 +	1.000 - 0.71	27	27		31	31	32
		0.709 - 0.60	36	35		41	40	41
		0.599 - 0.50	44	43		51	50	51
		0.499 - 0.00	56	55		67	64	66
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	12	12		19	19	20
		0.709 - 0.60	16	16		24	24	26
		0.599 - 0.50	19	19		30	29	32
		0.499 - 0.38	24	24		38	37	40
		0.379 - 0.25	34	33		55	53	57
		0.249 - 0.00	62	59		100	92	100
	0.250 - 0.499	1.000 - 0.71	17	17		26	26	28
		0.709 - 0.60	22	21		34	33	36
		0.599 - 0.50	27	26		42	41	44
		0.499 - 0.38	34	33		55	52	56
		0.379 - 0.00	49	47		80	75	81
	0.500 +	1.000 - 0.71	23	22		36	35	37
		0.709 - 0.60	29	29		47	46	49
		0.599 - 0.50	36	36		60	57	61
		0.499 - 0.00	47	45		77	73	78

OPAQUE WALL Uow

ILD 0 - 1.50:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.35	HC ≥ 5	15	0.41	0.50
	HC ≥ 10	15	0.51	0.59
	HC ≥ 15	15	0.59	0.62
	HC ≥ 5	88	0.43	0.54
	HC ≥ 10	88	0.56	0.66
	HC ≥ 15	88	0.65	0.69

ILD 1.51 - 3.00:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.35	HC ≥ 5	12	0.41	0.50
	HC ≥ 10	12	0.51	0.59
	HC ≥ 15	12	0.59	0.62
	HC ≥ 5	92	0.43	0.54
	HC ≥ 10	92	0.56	0.66
	HC ≥ 15	92	0.66	0.70

3.01 - 3.50

0.000 - 0.249	1.000 - 0.71	10	10	17	17	19
	0.709 - 0.60	13	12	22	22	25
	0.599 - 0.50	15	15	27	27	30
	0.499 - 0.38	19	19	34	34	38
	0.379 - 0.25	27	26	51	49	54
	0.249 - 0.00	48	46	91	84	95
0.250 - 0.499	1.000 - 0.71	13	13	24	23	26
	0.709 - 0.60	17	17	31	30	34
	0.599 - 0.50	21	21	39	38	42
	0.499 - 0.38	27	26	50	48	53
	0.379 - 0.00	38	37	74	70	77
0.500 +	1.000 - 0.71	18	17	33	32	35
	0.709 - 0.60	23	23	43	42	46
	0.599 - 0.50	29	28	55	53	58
	0.499 - 0.00	37	36	72	68	74

Daylight Sensing Controls

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.35	HC ≥ 5	10	0.41	0.49
	HC ≥ 10	10	0.50	0.58
	HC ≥ 15	10	0.58	0.61
	HC ≥ 5	91	0.42	0.53
	HC ≥ 10	91	0.55	0.65
	HC ≥ 15	91	0.65	0.69

	Min R-Value		
WALL BELOW GRADE:	0		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	0	0	0
Vertical	0	0	0

	Max Uo
ROOF:	0.045
WALL ADJACENT TO UNCOND SPACE:	0.42
FLOOR OVER UNCOND SPACE:	0.20

ALTERNATE COMPONENT PACKAGES FOR:

HDD50 = 1001 - 1750
CDD65 = 0 - 500
VSEW = 500 - 845

Astoria OR
Olympia WA
Portland OR
Salem OR
Seattle WA

Whidbey Island WA

TABLE 5.4-14

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	BASE CASE Uof 0.81 to 0.46	BASE CASE Uof 0.45 to 0.39	BASE CASE Uof 0.38 to 0	PERIMETER DAYLIGHTING N/A	PERIMETER DAYLIGHTING VLT ≥ SC
0 - 1.50	0.000 - 0.249	1.000 - 0.71	24	31	33		
		0.709 - 0.60	26	37	39		
		0.599 - 0.50	27	41	44		
		0.499 - 0.38	29	45	50		
		0.379 - 0.25	30	52	59		
		0.249 - 0.00	32	59	70		
	0.250 - 0.499	1.000 - 0.71	27	39	41		
		0.709 - 0.60	29	44	48		
		0.599 - 0.50	30	48	54		
		0.499 - 0.38	31	53	60		
		0.379 - 0.00	32	58	67		
	0.500 +	1.000 - 0.71	29	46	50		
		0.709 - 0.60	31	51	58		
		0.599 - 0.50	32	55	63		
		0.499 - 0.00	32	58	68		
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	22	27	28		
		0.709 - 0.60	25	32	34		
		0.599 - 0.50	27	37	39		
		0.499 - 0.38	29	42	45		
		0.379 - 0.25	32	49	54		
		0.249 - 0.00	35	60	69		
	0.250 - 0.499	1.000 - 0.71	28	34	36		
		0.709 - 0.60	29	40	43		
		0.599 - 0.50	30	45	49		
		0.499 - 0.38	32	50	55		
		0.379 - 0.00	34	57	65		
	0.500 +	1.000 - 0.71	29	42	45		
		0.709 - 0.60	32	48	52		
		0.599 - 0.50	33	52	58		
		0.499 - 0.00	34	57	64		

OPAQUE WALL Uow

ILD 0 - 1.50:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.096	HC ≥ 5	24	0.10	0.16
	HC ≥ 10	24	0.11	0.19
	HC ≥ 15	24	0.12	0.24
	HC ≥ 5	70	0.10	0.14
	HC ≥ 10	70	0.11	0.19
	HC ≥ 15	70	0.12	0.23

ILD 1.51 - 3.00:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.096	HC ≥ 5	22	0.10	0.17
	HC ≥ 10	22	0.12	0.23
	HC ≥ 15	22	0.13	0.28
	HC ≥ 5	69	0.10	0.16
	HC ≥ 10	69	0.11	0.22
	HC ≥ 15	69	0.13	0.27

3.01 - 3.50

0.000 - 0.249	1.000 - 0.71	21	25	26
	0.709 - 0.60	24	30	31
	0.599 - 0.50	26	34	36
	0.499 - 0.38	28	39	42
	0.379 - 0.25	31	47	51
	0.249 - 0.00	35	58	66
0.250 - 0.499	1.000 - 0.71	25	32	33
	0.709 - 0.60	28	38	40
	0.599 - 0.50	30	42	46
	0.499 - 0.38	32	48	52
	0.379 - 0.00	34	55	62
0.500 +	1.000 - 0.71	28	39	42
	0.709 - 0.60	31	46	49
	0.599 - 0.50	33	50	55
	0.499 - 0.00	34	55	61

Uow (HC<6)	HC RANGE	PCT FEN	INT INS	EXT INS
0.096	HC ≥ 5	21	0.10	0.17
	HC ≥ 10	21	0.12	0.24
	HC ≥ 15	21	0.14	0.30
	HC ≥ 5	66	0.10	0.17
	HC ≥ 10	66	0.11	0.23
	HC ≥ 15	66	0.13	0.29

Daylight Sensing Controls

	Min R-Value		
WALL BELOW GRADE:	9		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	10	13	10
Vertical	7	6	4

	Max Uo
ROOF:	0.064
WALL ADJACENT TO UNCOND SPACE:	0.14
FLOOR OVER UNCOND SPACE:	0.057

ALTERNATE COMPONENT PACKAGES FOR: Asheville NC, Medford OR — TABLE 5.4-15

HDD50 = 1001 - 1750
CDD65 = 501 - 1150
VSEW = 560 - 846

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	BASE CASE Uof 0.81 to 0.46	BASE CASE Uof 0.45 to 0.39	BASE CASE Uof 0.38 to 0	PERIMETER DAYLIGHTING Uof 0.81 to 0.46	PERIMETER DAYLIGHTING Uof 0.45 to 0	PERIMETER DAYLIGHTING Uof 0.38 to 0 (VLT ≥ SC)
0 - 1.50	0.000 - 0.249	1.000 - 0.71	20	24	25	22	26	27
		0.709 - 0.60	24	29	30	25	31	33
		0.599 - 0.50	26	34	35	27	36	38
		0.499 - 0.38	29	39	41	30	41	44
		0.379 - 0.25	33	47	51	33	50	55
		0.249 - 0.00	38	61	69	38	63	72
	0.250 - 0.499	1.000 - 0.71	25	31	32	26	33	35
		0.709 - 0.60	28	37	39	29	40	42
		0.599 - 0.50	31	42	45	31	45	49
		0.499 - 0.38	33	48	52	34	50	56
		0.379 - 0.00	36	57	63	37	59	67
	0.500 +	1.000 - 0.71	29	39	41	30	41	45
		0.709 - 0.60	32	46	49	33	48	53
		0.599 - 0.50	34	51	56	35	53	60
		0.499 - 0.00	36	57	63	37	59	67
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	18	20	20	22	27	28
		0.709 - 0.60	21	25	25	26	32	34
		0.599 - 0.50	24	29	30	29	37	40
		0.499 - 0.38	27	34	35	32	43	46
		0.379 - 0.25	32	42	45	36	52	58
		0.249 - 0.00	39	58	63	41	67	77
	0.250 - 0.499	1.000 - 0.71	22	26	27	27	34	36
		0.709 - 0.60	26	32	33	31	41	44
		0.599 - 0.50	29	37	39	33	46	51
		0.499 - 0.38	32	43	45	36	53	59
		0.379 - 0.00	37	53	57	40	62	71
	0.500 +	1.000 - 0.71	27	33	34	31	43	46
		0.709 - 0.60	31	40	42	35	50	55
		0.599 - 0.50	33	46	48	37	56	63
		0.499 - 0.00	36	52	56	39	62	71

OPAQUE WALL Uow

ILD 0 - 1.50:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.10	HC ≥ 5	20	0.11	0.15
	HC ≥ 10	20	0.13	0.19
	HC ≥ 15	20	0.16	0.20
	HC ≥ 5	72	0.11	0.14
	HC ≥ 10	72	0.13	0.17
	HC ≥ 15	72	0.14	0.18

ILD 1.51 - 3.00:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.10	HC ≥ 5	18	0.11	0.17
	HC ≥ 10	18	0.14	0.22
	HC ≥ 15	18	0.18	0.24
	HC ≥ 5	77	0.11	0.15
	HC ≥ 10	77	0.13	0.19
	HC ≥ 15	77	0.15	0.20

3.01 - 3.50

0.000 - 0.249	1.000 - 0.71	16	18	18	22	26	27
	0.709 - 0.60	19	22	22	25	31	33
	0.599 - 0.50	22	25	26	28	36	39
	0.499 - 0.38	25	30	31	31	42	45
	0.379 - 0.25	29	38	40	35	51	57
	0.249 - 0.00	36	52	57	40	65	75
0.250 - 0.499	1.000 - 0.71	20	23	23	26	33	35
	0.709 - 0.60	24	28	29	30	40	43
	0.599 - 0.50	26	33	34	32	45	50
	0.499 - 0.38	29	38	40	35	51	58
	0.379 - 0.00	34	47	51	39	61	70
0.500 +	1.000 - 0.71	24	29	30	31	41	45
	0.709 - 0.60	28	35	37	34	48	54
	0.599 - 0.50	31	41	43	36	54	61
	0.499 - 0.00	34	47	50	38	60	70

Daylight Sensing Controls

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.10	HC ≥ 5	10	0.11	0.17
	HC ≥ 10	10	0.15	0.23
	HC ≥ 15	10	0.18	0.26
	HC ≥ 5	75	0.11	0.15
	HC ≥ 10	75	0.13	0.19
	HC ≥ 15	75	0.15	0.20

	Min R-Value		
WALL BELOW GRADE:	8		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	15	12	10
Vertical	7	5	4

	Max Uo
ROOF:	0.063
WALL ADJACENT TO UNCOND SPACE:	0.16
FLOOR OVER UNCOND SPACE:	0.064

ALTERNATE COMPONENT PACKAGES FOR:

Prescott AZ
Winslow AZ
Yucca Flats NV

TABLE 5.4-16

HDD50 = 1001 - 1750
CDD65 = 1 - 1150
VSEW = > 845

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	Uof: BASE CASE 0.81 to 0.46	BASE CASE 0.45 to 0.39	BASE CASE 0.38 to 0	PERIMETER DAYLIGHTING 0.81 to 0.46	PERIMETER DAYLIGHTING 0.45 to 0	PERIMETER DAYLIGHTING 0.38 to 0 (VLT ≥ SC)
0 - 1.50	0.000 - 0.249	1.000 - 0.71	16	17	17	17	19	19
		0.709 - 0.60	18	21	21	20	23	24
		0.599 - 0.50	21	24	26	22	27	28
		0.499 - 0.38	24	29	30	25	31	33
		0.379 - 0.25	28	36	38	29	39	42
		0.249 - 0.00	35	50	54	36	53	58
	0.250 - 0.499	1.000 - 0.71	19	22	23	21	25	26
		0.709 - 0.60	23	27	28	24	30	31
		0.599 - 0.50	25	32	33	27	34	37
		0.499 - 0.38	28	37	39	30	40	43
		0.379 - 0.00	33	46	49	34	48	53
	0.500 +	1.000 - 0.71	24	29	30	25	31	33
		0.709 - 0.60	27	34	36	28	37	40
		0.599 - 0.50	30	39	42	31	42	46
		0.499 - 0.00	33	45	49	34	48	53
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	13	13	14	17	18	20
		0.709 - 0.60	16	17	17	20	23	25
		0.599 - 0.50	18	20	20	22	26	29
		0.499 - 0.38	20	23	24	25	31	34
		0.379 - 0.25	26	30	31	30	39	44
		0.249 - 0.00	33	43	46	37	53	62
	0.250 - 0.499	1.000 - 0.71	16	18	18	21	24	26
		0.709 - 0.60	19	22	22	24	29	32
		0.599 - 0.50	22	26	26	27	34	38
		0.499 - 0.38	25	30	31	30	40	44
		0.379 - 0.00	30	39	40	35	49	56
	0.500 +	1.000 - 0.71	20	23	24	25	31	34
		0.709 - 0.60	24	28	29	29	37	41
		0.599 - 0.50	27	33	34	32	42	48
		0.499 - 0.00	30	38	40	36	49	56

OPAQUE WALL Uow

ILD 0 - 1.50:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.11	HC ≥ 5	16	0.12	0.17
	HC ≥ 10	16	0.14	0.21
	HC ≥ 15	15	0.17	0.23
	HC ≥ 5	58	0.11	0.16
	HC ≥ 10	58	0.14	0.20
	HC ≥ 15	58	0.16	0.21

ILD 1.51 - 3.00:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.11	HC ≥ 5	13	0.12	0.19
	HC ≥ 10	13	0.16	0.25
	HC ≥ 15	13	0.20	0.27
	HC ≥ 5	62	0.12	0.17
	HC ≥ 10	62	0.15	0.22
	HC ≥ 15	62	0.18	0.23

3.01 - 3.50

0.000 - 0.249	1.000 - 0.71	11	11	11	15	17	19
	0.709 - 0.60	13	14	14	18	21	24
	0.599 - 0.50	15	17	17	21	25	28
	0.499 - 0.38	18	20	20	24	29	33
	0.379 - 0.25	22	26	27	28	37	42
	0.249 - 0.00	29	37	39	35	50	59
0.250 - 0.499	1.000 - 0.71	14	15	15	20	23	25
	0.709 - 0.60	17	19	19	23	28	31
	0.599 - 0.50	19	22	22	25	32	36
	0.499 - 0.38	22	26	27	28	37	43
	0.379 - 0.00	27	33	35	33	48	54
0.500 +	1.000 - 0.71	17	19	20	24	29	33
	0.709 - 0.60	21	24	25	27	35	40
	0.599 - 0.50	23	28	29	30	40	46
	0.499 - 0.00	26	33	34	33	45	53

Daylight Sensing Controls

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.11	HC ≥ 5	11	0.12	0.19
	HC ≥ 10	11	0.16	0.26
	HC ≥ 15	11	0.21	0.28
	HC ≥ 5	59	0.12	0.17
	HC ≥ 10	59	0.15	0.22
	HC ≥ 15	59	0.18	0.24

	Min R-Value				Max Uo
WALL BELOW GRADE:	8			ROOF:	0.055
UNHEATED SLAB ON GRADE:	24"	36"	48"	WALL ADJACENT TO UNCOND SPACE:	0.16
Horizontal	15	12	10		
Vertical	7	5	4	FLOOR OVER UNCOND SPACE:	0.065

ALTERNATE COMPONENT PACKAGES FOR:

HDD50 = 1001 - 1750
CDD65 = 1151 - 2000
VSEW = 600 - 845

TABLE 5.4-17

Charlotte NC, Chattanooga TN, Greensboro NC, Knoxville TN, Nashville TN

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	BASE CASE Uof 0.81 to 0.46	BASE CASE Uof 0.45 to 0.39	BASE CASE Uof 0.38 to 0	PERIMETER DAYLIGHTING Uof 0.81 to 0.46	PERIMETER DAYLIGHTING Uof 0.45 to 0	PERIMETER DAYLIGHTING Uof 0.38 to 0 (VLT ≥ SC)
0 - 1.50	0.000 - 0.249	1.000 - 0.71	16	18	18	18	20	20
		0.709 - 0.60	20	22	22	21	24	25
		0.599 - 0.50	23	26	28	24	28	30
		0.499 - 0.38	26	30	31	28	33	35
		0.379 - 0.25	32	39	40	34	43	46
		0.249 - 0.00	41	56	59	43	60	66
	0.250 - 0.499	1.000 - 0.71	21	23	24	23	26	27
		0.709 - 0.60	25	28	29	27	31	33
		0.599 - 0.50	28	33	34	30	37	39
		0.499 - 0.38	32	39	41	34	43	46
		0.379 - 0.00	38	50	52	40	54	58
	0.500 +	1.000 - 0.71	26	30	30	28	33	34
		0.709 - 0.60	30	36	37	32	40	42
		0.599 - 0.50	34	42	44	36	46	49
		0.499 - 0.00	38	49	51	40	53	58

OPAQUE WALL Uow

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.12	HC ≥ 5	10	0.14	0.18
	HC ≥ 10	10	0.17	0.22
	HC ≥ 15	10	0.19	0.24
	HC ≥ 5	60	0.14	0.18
	HC ≥ 10	60	0.16	0.21
	HC ≥ 15	60	0.19	0.23

Norfolk VA, Patuxent MD, Raleigh NC, Richmond VA, Roanoke VA

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	BASE CASE Uof 0.81 to 0.46	BASE CASE Uof 0.45 to 0.39	BASE CASE Uof 0.38 to 0	PERIMETER DAYLIGHTING Uof 0.81 to 0.46	PERIMETER DAYLIGHTING Uof 0.45 to 0	PERIMETER DAYLIGHTING Uof 0.38 to 0 (VLT ≥ SC)
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	13	14	14	18	20	21
		0.709 - 0.60	16	17	17	22	24	27
		0.599 - 0.50	19	21	21	25	29	31
		0.499 - 0.38	22	25	26	29	34	37
		0.379 - 0.25	28	32	33	35	44	49
		0.249 - 0.00	37	47	49	45	62	70
	0.250 - 0.499	1.000 - 0.71	17	18	19	23	26	28
		0.709 - 0.60	21	23	23	27	32	35
		0.599 - 0.50	24	27	27	31	37	41
		0.499 - 0.38	28	32	33	35	44	49
		0.379 - 0.00	34	41	43	41	55	63
	0.500 +	1.000 - 0.71	21	24	24	28	33	36
		0.709 - 0.60	26	29	30	33	40	45
		0.599 - 0.50	29	34	36	37	47	52
		0.499 - 0.00	33	41	42	41	55	61

OPAQUE WALL Uow

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.12	HC ≥ 5	13	0.14	0.20
	HC ≥ 10	13	0.18	0.26
	HC ≥ 15	13	0.23	0.29
	HC ≥ 5	70	0.14	0.18
	HC ≥ 10	70	0.17	0.23
	HC ≥ 15	70	0.20	0.25

3.01 - 3.50

0.000 - 0.249	1.000 - 0.71	11	12	12	17	18	20
	0.709 - 0.60	14	14	15	20	23	25
	0.599 - 0.50	16	17	17	23	27	30
	0.499 - 0.38	19	21	21	27	32	36
	0.379 - 0.25	24	27	28	33	41	47
	0.249 - 0.00	32	40	42	42	58	68
0.250 - 0.499	1.000 - 0.71	14	15	15	22	24	27
	0.709 - 0.60	18	19	19	25	30	34
	0.599 - 0.50	20	23	23	29	35	39
	0.499 - 0.38	24	27	28	33	41	47
	0.379 - 0.00	29	35	36	39	52	60
0.500 +	1.000 - 0.71	18	20	20	26	31	35
	0.709 - 0.60	22	24	25	31	38	43
	0.599 - 0.50	25	29	29	34	44	50
	0.499 - 0.00	29	34	35	38	51	59

Daylight Sensing Controls

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.12	HC ≥ 5	11	0.14	0.20
	HC ≥ 10	11	0.19	0.27
	HC ≥ 15	11	0.24	0.30
	HC ≥ 5	60	0.14	0.19
	HC ≥ 10	60	0.17	0.23
	HC ≥ 15	60	0.20	0.25

	Min R-Value		
WALL BELOW GRADE:	8		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	13	11	9
Vertical	8	5	4

	Max Uo
ROOF:	0.066
WALL ADJACENT TO UNCOND SPACE:	0.17
FLOOR OVER UNCOND SPACE:	0.074

ALTERNATE COMPONENT PACKAGES FOR:

HDD50 = 1001 - 1750
CDD65 = 1151 - 2000
VSEW = > 845

Albuquerque NM
Amarillo TX
Lubbock TX
Oklahoma City OK
Roswell NM

Truth or Consequences NM
Tucumcari NM

TABLE 5.4-18

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	BASE CASE 0.81 to 0.46	BASE CASE 0.45 to 0.39	BASE CASE 0.38 to 0	PERIMETER DAYLIGHTING 0.81 to 0.46	PERIMETER DAYLIGHTING 0.45 to 0	PERIMETER DAYLIGHTING 0.38 to 0 (VLT ≥ SC)
0 - 1.50	0.000 - 0.249	1.000 - 0.71	14	15	18	15	17	17
		0.709 - 0.60	17	19	19	18	21	22
		0.599 - 0.50	19	22	23	20	24	25
		0.499 - 0.38	22	26	27	23	28	30
		0.379 - 0.25	27	33	35	28	36	38
		0.249 - 0.00	33	47	50	35	49	54
	0.250 - 0.499	1.000 - 0.71	18	20	21	19	22	23
		0.709 - 0.60	21	25	26	22	27	28
		0.599 - 0.50	24	29	30	25	31	33
		0.499 - 0.38	27	34	35	28	36	39
		0.379 - 0.00	31	42	46	32	45	49
	0.500 +	1.000 - 0.71	22	26	27	23	28	30
		0.709 - 0.60	25	31	33	27	34	36
		0.599 - 0.50	28	36	38	29	39	42
		0.499 - 0.00	31	42	45	32	45	49
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	11	12	12	15	16	18
		0.709 - 0.60	14	15	15	18	20	22
		0.599 - 0.50	16	18	18	20	23	26
		0.499 - 0.38	19	21	22	23	28	31
		0.379 - 0.25	23	27	28	28	35	40
		0.249 - 0.00	31	39	42	36	49	57
	0.250 - 0.499	1.000 - 0.71	15	16	16	19	22	24
		0.709 - 0.60	18	20	20	22	26	29
		0.599 - 0.50	20	23	24	25	30	34
		0.499 - 0.38	23	27	28	28	36	40
		0.379 - 0.00	28	35	37	33	46	51
	0.500 +	1.000 - 0.71	18	21	21	23	28	31
		0.709 - 0.60	22	25	26	27	33	37
		0.599 - 0.50	24	29	30	29	38	43
		0.499 - 0.00	28	35	36	33	44	51

Uof

OPAQUE WALL Uow

ILD 0 - 1.50:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.11	HC ≥ 5	14	0.12	0.18
	HC ≥ 10	14	0.14	0.21
	HC ≥ 15	14	0.17	0.22
	HC ≥ 5	54	0.11	0.16
	HC ≥ 10	54	0.14	0.19
	HC ≥ 15	54	0.16	0.21

ILD 1.51 - 3.00:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.11	HC ≥ 5	11	0.12	0.18
	HC ≥ 10	11	0.16	0.23
	HC ≥ 15	11	0.19	0.26
	HC ≥ 5	57	0.12	0.17
	HC ≥ 10	57	0.15	0.21
	HC ≥ 15	57	0.17	0.23

3.01 - 3.50

0.000 - 0.249	1.000 - 0.71	10	10	10	14	15	17
	0.709 - 0.60	12	13	13	16	18	21
	0.599 - 0.50	14	15	15	19	22	25
	0.499 - 0.38	16	18	18	21	26	29
	0.379 - 0.25	20	23	24	26	33	38
	0.249 - 0.00	27	34	35	33	46	54
0.250 - 0.499	1.000 - 0.71	12	13	14	17	20	22
	0.709 - 0.60	15	17	17	20	24	28
	0.599 - 0.50	17	20	20	23	28	33
	0.499 - 0.38	20	23	24	26	33	38
	0.379 - 0.00	24	30	31	30	41	49
0.500 +	1.000 - 0.71	16	17	18	21	25	29
	0.709 - 0.60	19	21	22	25	31	36
	0.599 - 0.50	21	25	26	27	35	41
	0.499 - 0.00	24	29	31	30	41	48

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.11	HC ≥ 5	10	0.12	0.18
	HC ≥ 10	10	0.16	0.24
	HC ≥ 15	10	0.20	0.26
	HC ≥ 5	54	0.12	0.17
	HC ≥ 10	54	0.16	0.22
	HC ≥ 15	54	0.18	0.23

Daylight Sensing Controls

	Min R-Value		
WALL BELOW GRADE	8		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	14	11	9
Vertical	7	5	4

	Max Uo
ROOF:	0.059
WALL ADJACENT TO UNCOND SPACE:	0.17
FLOOR OVER UNCOND SPACE:	0.070

ALTERNATE COMPONENT PACKAGES FOR:

HDD50 = 1001 - 1750
CDD65 = 2001 - 3250
VSEW = 580 - 845

Fort Smith AR
Memphis TN
Tulsa OK

TABLE 5.4-19

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	BASE CASE Uof 0.81 to 0.46	BASE CASE Uof 0.45 to 0.39	BASE CASE Uof 0.38 to 0	PERIMETER DAYLIGHTING Uof 0.81 to 0.46	PERIMETER DAYLIGHTING Uof 0.45 to 0	PERIMETER DAYLIGHTING Uof 0.38 to 0 (VLT ≥ SC)
0 - 1.50	0.000 - 0.249	1.000 - 0.71	14	15	15	16	17	17
		0.709 - 0.60	17	19	19	19	21	22
		0.599 - 0.50	20	22	22	22	25	26
		0.499 - 0.38	24	26	27	26	29	31
		0.379 - 0.25	30	35	36	32	38	41
		0.249 - 0.00	41	52	54	43	57	62
	0.250 - 0.499	1.000 - 0.71	18	20	20	20	22	23
		0.709 - 0.60	22	25	25	24	27	29
		0.599 - 0.50	26	29	30	28	32	34
		0.499 - 0.38	30	35	36	32	39	41
		0.379 - 0.00	37	45	47	40	50	53
	0.500 +	1.000 - 0.71	23	26	26	25	29	30
		0.709 - 0.60	28	32	32	30	35	37
		0.599 - 0.50	32	37	38	34	41	44
		0.499 - 0.00	36	44	46	39	49	52
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	11	11	11	15	16	18
		0.709 - 0.60	13	14	14	19	20	22
		0.599 - 0.50	16	17	17	22	24	27
		0.499 - 0.38	19	20	20	25	29	32
		0.379 - 0.25	24	27	27	32	38	43
		0.249 - 0.00	34	41	42	43	56	65
	0.250 - 0.499	1.000 - 0.71	14	15	15	20	21	24
		0.709 - 0.60	17	19	19	24	27	30
		0.599 - 0.50	20	22	22	28	32	35
		0.499 - 0.38	24	27	27	32	38	43
		0.379 - 0.00	30	35	36	39	49	56
	0.500 +	1.000 - 0.71	18	19	19	25	28	31
		0.709 - 0.60	22	24	24	30	34	39
		0.599 - 0.50	26	29	29	34	40	46
		0.499 - 0.00	30	34	35	39	48	56

OPAQUE WALL Uow

ILD 0 - 1.50:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.13	HC ≥ 5	14	0.14	0.20
	HC ≥ 10	14	0.18	0.25
	HC ≥ 15	14	0.22	0.27
	HC ≥ 5	62	0.14	0.20
	HC ≥ 10	62	0.18	0.24
	HC ≥ 15	62	0.21	0.26

ILD 1.51 - 3.00:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.13	HC ≥ 5	11	0.16	0.21
	HC ≥ 10	11	0.19	0.27
	HC ≥ 15	11	0.24	0.30
	HC ≥ 5	65	0.14	0.20
	HC ≥ 10	65	0.18	0.26
	HC ≥ 16	65	0.23	0.28

3.01 - 3.50

0.000 - 0.249	1.000 - 0.71	9	9	9	14	14	17
	0.709 - 0.60	11	11	11	17	18	21
	0.599 - 0.50	13	14	14	20	21	25
	0.499 - 0.38	15	16	17	23	26	30
	0.379 - 0.25	20	22	22	29	34	40
	0.249 - 0.00	28	33	34	39	51	61
0.250 - 0.499	1.000 - 0.71	12	12	12	18	19	22
	0.709 - 0.60	14	16	15	22	24	28
	0.599 - 0.50	17	18	18	26	28	33
	0.499 - 0.38	20	22	22	29	34	40
	0.379 - 0.00	25	29	29	35	44	53
0.500 +	1.000 - 0.71	15	16	16	22	25	29
	0.709 - 0.60	18	19	20	27	31	36
	0.599 - 0.50	21	23	23	30	36	43
	0.499 - 0.00	24	28	28	35	43	52

Daylight Sensing Controls

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.13	HC ≥ 5	9	0.15	0.22
	HC ≥ 10	9	0.19	0.28
	HC ≥ 15	9	0.24	0.31
	HC ≥ 5	61	0.16	0.21
	HC ≥ 10	61	0.18	0.26
	HC ≥ 15	61	0.23	0.29

	Min R-Value		
WALL BELOW GRADE:	7		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	12	10	8
Vertical	6	5	4

	Max Uo
ROOF:	0.058
WALL ADJACENT TO UNCOND SPACE:	0.19
FLOOR OVER UNCOND SPACE:	0.083

ALTERNATE COMPONENT PACKAGES FOR:

HDD50 = 1751 - 2000
CDD65 = 0 - 1150
VSEW = 560 - 845

Baltimore MD, Boston MA, Charleston WV, Columbus OH, Covington KY, Dayton OH, Harrisburg PA, Lewiston ID, Newark NJ, New York NY, New York (LAG) NY, Philadelphia PA, Redmond OR, Washington DC, Yakima WA

TABLE 5.4-20

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	Uof BASE CASE 0.68 to 0.46	Uof BASE CASE 0.45 to 0.39	Uof BASE CASE 0.38 to 0	Uof PERIMETER DAYLIGHTING 0.68 to 0.46	Uof PERIMETER DAYLIGHTING 0.45 to 0	Uof PERIMETER DAYLIGHTING 0.38 to 0 (VLT ≥ SC)
0 - 1.50	0.000 - 0.249	1.000 - 0.71	22	26	27	23	27	29
		0.709 - 0.60	25	30	32	26	32	34
		0.599 - 0.50	27	34	37	28	36	39
		0.499 - 0.38	30	39	42	30	40	44
		0.379 - 0.25	33	45	51	33	46	52
		0.249 - 0.00	36	54	63	36	54	63
	0.250 - 0.499	1.000 - 0.71	26	33	35	27	34	37
		0.709 - 0.60	29	38	41	30	39	43
		0.599 - 0.50	31	42	46	31	43	48
		0.499 - 0.38	33	46	52	33	47	53
		0.379 - 0.00	36	52	60	35	52	61
	0.500 +	1.000 - 0.71	30	39	43	30	41	45
		0.709 - 0.60	33	45	49	33	46	52
		0.599 - 0.50	34	49	55	34	49	56
		0.499 - 0.00	36	52	60	35	53	61
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	20	22	22	24	28	29
		0.709 - 0.60	23	26	27	27	33	35
		0.599 - 0.50	25	30	32	29	37	40
		0.499 - 0.38	28	35	37	32	41	46
		0.379 - 0.25	32	42	46	35	48	55
		0.249 - 0.00	38	53	60	39	58	68
	0.250 - 0.499	1.000 - 0.71	24	28	29	28	35	37
		0.709 - 0.60	27	33	35	31	40	44
		0.599 - 0.50	30	38	40	33	44	50
		0.499 - 0.38	33	42	46	35	49	56
		0.379 - 0.00	36	50	55	38	55	65
	0.500 +	1.000 - 0.71	28	35	37	32	42	47
		0.709 - 0.60	32	40	43	34	47	54
		0.599 - 0.50	34	45	49	36	51	59
		0.499 - 0.00	36	50	55	38	55	65

OPAQUE WALL Uow

ILD 0 - 1.50:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.088	HC ≥ 5	22	0.096	0.12
	HC ≥ 10	22	0.11	0.15
	HC ≥ 15	22	0.12	0.16
	HC ≥ 5	63	0.093	0.11
	HC ≥ 10	63	0.10	0.13
	HC ≥ 15	63	0.11	0.14

ILD 1.51 - 3.00:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.088	HC ≥ 5	20	0.097	0.14
	HC ≥ 10	20	0.11	0.17
	HC ≥ 15	20	0.13	0.18
	HC ≥ 5	68	0.096	0.12
	HC ≥ 10	68	0.10	0.14
	HC ≥ 15	68	0.11	0.15

3.01 - 3.50	0.000 - 0.249	1.000 - 0.71	18	19	20	23	27	28
		0.709 - 0.60	21	23	24	26	32	34
		0.599 - 0.50	23	27	28	29	36	39
		0.499 - 0.38	26	31	33	31	41	45
		0.379 - 0.25	30	38	41	34	47	54
		0.249 - 0.00	36	49	55	39	57	67
	0.250 - 0.499	1.000 - 0.71	22	25	26	27	34	37
		0.709 - 0.60	25	30	31	30	39	44
		0.599 - 0.50	28	34	36	33	43	49
		0.499 - 0.38	30	39	42	35	48	55
		0.379 - 0.00	34	46	51	38	54	64
	0.500 +	1.000 - 0.71	26	31	33	31	41	46
		0.709 - 0.60	29	36	39	34	46	53
		0.599 - 0.50	32	41	44	36	50	59
		0.499 - 0.00	34	46	50	38	54	64

Daylight Sensing Controls

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.088	HC ≥ 5	10	0.098	0.14
	HC ≥ 10	10	0.11	0.18
	HC ≥ 15	10	0.13	0.19
	HC ≥ 5	67	0.095	0.12
	HC ≥ 10	67	0.10	0.14
	HC ≥ 15	67	0.11	0.15

	Min R-Value		
WALL BELOW GRADE:	9		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	17	14	11
Vertical	8	6	4

	Max Uo
ROOF:	0.055
WALL ADJACENT TO UNCOND SPACE:	0.13
FLOOR OVER UNCOND SPACE:	0.048

ALTERNATE COMPONENT PACKAGES FOR:

HDD50 = 2001 - 3200
CDD65 = 0 - 1150
VSEW = 500 - 845

Akron OH	Erie PA	Providence RI	TABLE 5.4-21
Allentown PA	Hartford CT	South Bend IN	
Burlington IA	Indianapolis IN	Spokane WA	
Chicago IL	Omaha NE	Toledo OH	
Detroit MI	Pittsburgh PA	Youngstown OH	

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	BASE CASE Uof 0.60 to 0.46	BASE CASE Uof 0.45 to 0.39	BASE CASE Uof 0.38 to 0	PERIMETER DAYLIGHTING Uof 0.60 to 0.46	PERIMETER DAYLIGHTING Uof 0.45 to 0	PERIMETER DAYLIGHTING Uof 0.38 to 0 (VLT ≥ SC)
0 - 1.50	0.000 - 0.249	1.000 - 0.71	21	26	28	21	27	29
		0.709 - 0.60	24	30	33	23	31	34
		0.599 - 0.50	25	34	37	25	34	38
		0.499 - 0.38	26	37	41	26	37	42
		0.379 - 0.25	28	41	47	27	40	47
		0.249 - 0.00	29	46	54	28	44	53
	0.250 - 0.499	1.000 - 0.71	25	32	35	24	33	37
		0.709 - 0.60	26	36	41	26	37	41
		0.599 - 0.50	27	39	44	27	39	45
		0.499 - 0.38	28	42	48	27	41	48
		0.379 - 0.00	29	45	53	28	44	52
	0.500 +	1.000 - 0.71	27	38	42	26	38	43
		0.709 - 0.60	28	41	47	27	41	48
		0.599 - 0.50	29	44	51	28	43	50
		0.499 - 0.00	30	46	54	29	44	53
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	19	23	23	22	27	29
		0.709 - 0.60	22	27	28	24	32	34
		0.599 - 0.50	24	30	32	26	35	39
		0.499 - 0.38	26	34	37	28	38	43
		0.379 - 0.25	29	40	44	30	43	49
		0.249 - 0.00	32	47	54	32	49	57
	0.250 - 0.499	1.000 - 0.71	23	28	30	25	33	37
		0.709 - 0.60	26	33	36	27	38	43
		0.599 - 0.50	28	36	40	29	40	47
		0.499 - 0.38	29	40	45	30	43	50
		0.379 - 0.00	31	45	52	32	47	55
	0.500 +	1.000 - 0.71	26	34	37	28	39	45
		0.709 - 0.60	29	39	43	29	42	50
		0.599 - 0.50	30	42	47	30	45	53
		0.499 - 0.00	32	46	52	32	47	56

OPAQUE WALL Uow

ILD 0 - 1.50:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.080	HC ≥ 5	21	0.084	0.10
	HC ≥ 10	21	0.092	0.12
	HC ≥ 15	21	0.099	0.12
	HC ≥ 5	54	0.083	0.10
	HC ≥ 10	54	0.090	0.11
	HC ≥ 15	54	0.095	0.12

ILD 1.51 - 3.00:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.080	HC ≥ 5	19	0.085	0.11
	HC ≥ 10	19	0.095	0.13
	HC ≥ 15	19	0.10	0.14
	HC ≥ 5	57	0.083	0.10
	HC ≥ 10	57	0.089	0.11
	HC ≥ 15	57	0.096	0.12

3.01 - 3.50							
0.000 - 0.249	1.000 - 0.71	18	20	21	22	27	29
	0.709 - 0.60	20	24	25	24	31	34
	0.599 - 0.50	23	28	29	26	34	38
	0.499 - 0.38	25	31	34	27	38	43
	0.379 - 0.25	28	37	41	30	43	49
	0.249 - 0.00	31	45	51	32	48	57
0.250 - 0.499	1.000 - 0.71	21	26	27	25	33	36
	0.709 - 0.60	24	30	32	27	37	42
	0.599 - 0.50	26	34	37	28	40	46
	0.499 - 0.38	28	37	41	30	43	50
	0.379 - 0.00	30	43	48	32	47	55
0.500 +	1.000 - 0.71	25	31	34	28	38	44
	0.709 - 0.60	27	36	39	29	42	49
	0.599 - 0.50	29	39	44	30	44	53
	0.499 - 0.00	30	43	48	31	47	56

Daylight Sensing Controls

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.080	HC ≥ 5	18	0.086	0.11
	HC ≥ 10	18	0.097	0.14
	HC ≥ 15	18	0.10	0.15
	HC ≥ 5	57	0.083	0.10
	HC ≥ 10	57	0.090	0.12
	HC ≥ 15	57	0.096	0.12

	Min R-Value		
WALL BELOW GRADE:	10		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	17	14	11
Vertical	8	6	4

	Max Uo
ROOF:	0.054
WALL ADJACENT TO UNCOND SPACE:	0.13
FLOOR OVER UNCOND SPACE:	0.047

ALTERNATE COMPONENT PACKAGES FOR:

HDD50 = 1751 - 3200
CDD65 = 0 - 1150
VSEW = > 846

Boise ID, Cedar UT, Clayton NM, Colorado Springs CO, Denver CO, Goodland KS, Lovelock NV, Mount Shasta CA, Pueblo CO, Reno NV, Salt Lake City UT, Tonopah NV, Winnemucca NV

TABLE 5.4-22

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	BASE CASE Uof 0.68 to 0.46	BASE CASE Uof 0.45 to 0.39	BASE CASE Uof 0.38 to 0	PERIMETER DAYLIGHTING Uof 0.68 to 0.46	PERIMETER DAYLIGHTING Uof 0.45 to 0	PERIMETER DAYLIGHTING Uof 0.38 to 0 (VLT ≥ SC)
0 - 1.50	0.000 - 0.249	1.000 - 0.71	22	24	25	23	26	27
		0.709 - 0.60	25	29	31	26	31	33
		0.599 - 0.50	27	33	35	28	35	38
		0.499 - 0.38	30	38	41	30	39	43
		0.379 - 0.25	33	45	49	33	46	52
		0.249 - 0.00	37	54	62	37	55	63
	0.250 - 0.499	1.000 - 0.71	28	31	33	27	33	36
		0.709 - 0.60	29	37	39	30	39	42
		0.599 - 0.50	32	41	45	32	43	47
		0.499 - 0.38	34	46	50	34	47	53
		0.379 - 0.00	37	52	59	36	53	61
	0.500 +	1.000 - 0.71	31	39	41	31	40	44
		0.709 - 0.60	33	44	48	33	46	51
		0.599 - 0.50	35	48	54	35	49	56
		0.499 - 0.00	37	53	60	37	53	62
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	19	20	21	23	26	28
		0.709 - 0.60	22	25	25	26	31	33
		0.599 - 0.50	25	29	30	29	36	39
		0.499 - 0.38	28	33	35	32	41	45
		0.379 - 0.25	32	41	44	36	48	54
		0.249 - 0.00	39	52	58	40	58	68
	0.250 - 0.499	1.000 - 0.71	23	26	27	28	34	36
		0.709 - 0.60	27	32	33	31	39	43
		0.599 - 0.50	30	36	38	34	44	49
		0.499 - 0.38	33	41	44	36	48	55
		0.379 - 0.00	37	49	54	39	55	64
	0.500 +	1.000 - 0.71	28	33	35	32	41	45
		0.709 - 0.60	32	39	41	35	47	53
		0.599 - 0.50	34	44	47	37	51	59
		0.499 - 0.00	37	49	54	39	56	65

OPAQUE WALL Uow

ILD 0 - 1.50:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.092	HC ≥ 5	22	0.10	0.13
	HC ≥ 10	22	0.11	0.15
	HC ≥ 15	22	0.12	0.16
	HC ≥ 5	63	0.098	0.12
	HC ≥ 10	63	0.10	0.13
	HC ≥ 15	63	0.11	0.14

ILD 1.51 - 3.00:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.092	HC ≥ 5	19	0.10	0.14
	HC ≥ 10	19	0.12	0.18
	HC ≥ 15	19	0.14	0.19
	HC ≥ 5	68	0.099	0.12
	HC ≥ 10	68	0.11	0.14
	HC ≥ 15	68	0.12	0.16

3.01 - 3.50

0.000 - 0.249	1.000 - 0.71	17	18	18	22	26	27
	0.709 - 0.60	20	22	23	26	31	33
	0.599 - 0.50	22	26	26	28	35	38
	0.499 - 0.38	25	30	31	31	39	44
	0.379 - 0.25	30	37	39	35	47	53
	0.249 - 0.00	36	48	53	40	57	67
0.250 - 0.499	1.000 - 0.71	21	23	24	27	33	35
	0.709 - 0.60	24	28	29	30	38	42
	0.599 - 0.50	27	32	34	33	43	48
	0.499 - 0.38	30	37	40	35	47	54
	0.379 - 0.00	36	45	49	38	54	63
0.500 +	1.000 - 0.71	25	30	31	31	40	44
	0.709 - 0.60	29	35	37	34	46	52
	0.599 - 0.50	32	39	42	36	50	58
	0.499 - 0.00	36	44	48	38	54	64

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.092	HC ≥ 5	17	0.10	0.15
	HC ≥ 10	17	0.12	0.19
	HC ≥ 15	17	0.14	0.20
	HC ≥ 5	67	0.099	0.13
	HC ≥ 10	67	0.11	0.15
	HC ≥ 15	67	0.12	0.15

Daylight Sensing Controls

	Min R-Value		
WALL BELOW GRADE:	9		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	16	14	10
Vertical	7	6	4

	Max Uo
ROOF:	0.052
WALL ADJACENT TO UNCOND SPACE:	0.13
FLOOR OVER UNCOND SPACE:	0.049

ALTERNATE COMPONENT PACKAGES FOR:

HDD50 = 1751 - 3200
CDD65 = 1151 - 2000
VSEW = 560 - 845

Columbia MO
Evansville IN
Lexington KY
Louisville KY
Saint Louis MO

Springfield IL
Topeka KS

TABLE 5.4-23

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	Uof BASE CASE 0.81 to 0.46	Uof BASE CASE 0.45 to 0.39	Uof BASE CASE 0.38 to 0	PERIMETER DAYLIGHTING 0.81 to 0.46	PERIMETER DAYLIGHTING 0.45 to 0	PERIMETER DAYLIGHTING 0.38 to 0 (VLT ≥ SC)
0 - 1.50	0.000 - 0.249	1.000 - 0.71	17	19	19	18	20	21
		0.709 - 0.60	20	23	23	21	25	28
		0.599 - 0.50	22	26	27	24	29	31
		0.499 - 0.38	25	31	32	27	34	36
		0.379 - 0.25	30	39	41	31	42	46
		0.249 - 0.00	37	54	58	38	57	63
	0.250 - 0.499	1.000 - 0.71	21	24	25	22	27	28
		0.709 - 0.60	24	29	30	26	32	34
		0.599 - 0.50	27	34	36	28	37	40
		0.499 - 0.38	30	40	42	31	43	46
		0.379 - 0.00	35	49	52	36	52	57
	0.500 +	1.000 - 0.71	25	31	32	27	33	36
		0.709 - 0.60	29	37	39	30	40	43
		0.599 - 0.50	31	42	45	33	45	49
		0.499 - 0.00	34	48	52	36	52	57
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	14	15	15	18	21	22
		0.709 - 0.60	17	19	19	22	25	27
		0.599 - 0.50	19	22	22	25	30	32
		0.499 - 0.38	22	26	27	28	35	38
		0.379 - 0.25	27	33	35	33	44	49
		0.249 - 0.00	35	47	50	40	59	68
	0.250 - 0.499	1.000 - 0.71	18	20	20	23	27	29
		0.709 - 0.60	21	24	25	27	33	36
		0.599 - 0.50	24	28	29	30	38	42
		0.499 - 0.38	27	33	35	33	44	49
		0.379 - 0.00	32	42	44	38	54	62
	0.500 +	1.000 - 0.71	22	25	26	27	34	37
		0.709 0.60	25	31	32	31	41	45
		0.599 - 0.50	28	36	37	34	47	52
		0.499 - 0.00	32	41	44	37	53	61

OPAQUE WALL Uow

ILD 0 - 1.50:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.11	HC ≥ 5	17	0.11	0.15
	HC ≥ 10	17	0.13	0.18
	HC ≥ 15	17	0.15	0.19
	HC ≥ 5	63	0.11	0.14
	HC ≥ 10	63	0.13	0.17
	HC ≥ 15	63	0.14	0.18

ILD 1.51 - 3.00:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.11	HC ≥ 5	14	0.11	0.16
	HC ≥ 10	14	0.14	0.20
	HC ≥ 15	14	0.17	0.22
	HC ≥ 5	68	0.11	0.15
	HC ≥ 10	68	0.13	0.18
	HC ≥ 15	68	0.15	0.19

3.01 - 3.50

0.000 - 0.249	1.000 - 0.71	12	13	13	17	19	21
	0.709 - 0.60	14	16	16	20	24	26
	0.599 - 0.50	17	19	19	23	28	31
	0.499 - 0.38	19	22	23	26	33	37
	0.379 - 0.25	24	29	30	31	41	47
	0.249 - 0.00	31	41	43	38	56	66
0.250 - 0.499	1.000 - 0.71	15	17	17	22	25	28
	0.709 - 0.60	18	21	21	25	31	35
	0.599 - 0.50	21	24	25	28	36	40
	0.499 - 0.38	24	29	30	31	41	47
	0.379 - 0.00	29	36	38	35	51	59
0.500 +	1.000 - 0.71	19	21	22	26	32	36
	0.709 - 0.60	22	26	27	29	38	44
	0.599 - 0.50	25	30	32	32	44	51
	0.499 - 0.00	28	36	37	35	50	59

Daylight Sensing Controls

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.11	HC ≥ 5	12	0.11	0.16
	HC ≥ 10	12	0.14	0.21
	HC ≥ 15	12	0.17	0.23
	HC ≥ 5	66	0.11	0.15
	HC ≥ 10	66	0.13	0.18
	HC ≥ 15	66	0.15	0.19

	Min R-Value		
WALL BELOW GRADE:	9		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	15	13	10
Vertical	7	6	4

	Max Uo
ROOF:	0.056
WALL ADJACENT TO UNCOND SPACE:	0.15
FLOOR OVER UNCOND SPACE:	0.058

ALTERNATE COMPONENT PACKAGES FOR:

Dodge City KS
Grand Junction CO

TABLE 5.4-24

HDD60 = 1751 - 3200
CDD65 = 1161 - 2000
VSEW = > 845

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	BASE CASE Uof 0.81 to 0.46	BASE CASE Uof 0.45 to 0.39	BASE CASE Uof 0.38 to 0	PERIMETER DAYLIGHTING Uof 0.81 to 0.46	PERIMETER DAYLIGHTING Uof 0.45 to 0	PERIMETER DAYLIGHTING Uof 0.38 to 0 (VLT ≥ SC)
0 - 1.50	0.000 - 0.249	1.000 - 0.71	15	17	17	16	19	19
		0.709 - 0.60	18	21	21	19	23	24
		0.599 - 0.50	20	24	25	21	26	28
		0.499 - 0.38	22	28	30	23	30	32
		0.379 - 0.25	26	35	38	27	37	41
		0.249 - 0.00	31	47	52	32	49	56
	0.250 - 0.499	1.000 - 0.71	19	22	23	20	24	25
		0.709 - 0.60	22	27	28	23	29	31
		0.599 - 0.50	24	31	33	25	33	36
		0.499 - 0.38	26	36	38	27	38	41
		0.379 - 0.00	30	44	47	31	46	51
	0.500 +	1.000 - 0.71	22	28	29	23	30	32
		0.709 - 0.60	25	34	35	26	36	39
		0.599 - 0.50	28	38	41	28	40	44
		0.499 - 0.00	30	43	47	31	46	51
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	12	13	14	16	18	20
		0.709 - 0.60	15	17	17	19	22	24
		0.599 - 0.50	17	20	20	21	26	28
		0.499 - 0.38	19	23	24	23	30	34
		0.379 - 0.25	23	29	31	27	37	42
		0.249 - 0.00	30	41	44	33	50	58
	0.250 - 0.499	1.000 - 0.71	16	18	18	20	24	26
		0.709 - 0.60	18	22	22	23	28	32
		0.599 - 0.50	21	26	26	25	33	37
		0.499 - 0.38	23	30	31	27	38	43
		0.379 - 0.00	28	37	39	31	46	53
	0.500 +	1.000 - 0.71	19	23	23	23	30	33
		0.709 - 0.60	22	27	29	26	35	40
		0.599 - 0.50	25	32	33	29	40	46
		0.499 - 0.00	27	37	39	31	45	53

OPAQUE WALL Uow

ILD 0 - 1.50:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.097	HC ≥ 5	15	0.10	0.14
	HC ≥ 10	15	0.12	0.16
	HC ≥ 15	15	0.13	0.17
	HC ≥ 5	50	0.10	0.13
	HC ≥ 10	50	0.11	0.15
	HC ≥ 15	50	0.13	0.16

ILD 1.51 - 3.00:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.097	HC ≥ 5	12	0.10	0.14
	HC ≥ 10	12	0.12	0.18
	HC ≥ 15	12	0.14	0.19
	HC ≥ 5	50	0.10	0.14
	HC ≥ 10	50	0.12	0.16
	HC ≥ 15	50	0.13	0.17

3.01 - 3.50

0.000 - 0.249	1.000 - 0.71	11	11	12	15	17	19
	0.709 - 0.60	13	14	14	17	21	23
	0.599 - 0.50	15	17	17	20	24	27
	0.499 - 0.38	17	20	20	22	28	32
	0.379 - 0.25	21	25	27	26	35	41
	0.249 - 0.00	27	30	38	31	47	56
0.250 - 0.499	1.000 - 0.71	14	15	15	18	22	25
	0.709 - 0.60	16	19	19	21	27	30
	0.599 - 0.50	18	22	22	23	31	35
	0.499 - 0.38	21	26	27	26	35	41
	0.379 - 0.00	25	32	34	29	43	51
0.500 +	1.000 - 0.71	17	19	20	22	28	32
	0.709 - 0.60	19	24	24	25	33	38
	0.599 - 0.50	22	27	28	27	38	44
	0.499 - 0.00	24	32	33	29	43	50

Daylight Sensing Controls

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.097	HC ≥ 5	11	0.10	0.15
	HC ≥ 10	11	0.12	0.18
	HC ≥ 15	11	0.15	0.20
	HC ≥ 5	56	0.10	0.14
	HC ≥ 10	56	0.12	0.17
	HC ≥ 15	56	0.14	0.18

	Min R-Value		
WALL BELOW GRADE:	9		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	16	13	10
Vertical	7	6	4

	Max Uo
ROOF:	0.053
WALL ADJACENT TO UNCOND SPACE:	0.14
FLOOR OVER UNCOND SPACE:	0.056

ALTERNATE COMPONENT PACKAGES FOR:

HDD65 = 3201 - 4000
CDD65 = 0 - 1150
VSEW = 560 - 845

Albany NY, Buffalo NY, Concord NH, Des Moines IA, Grand Island NE, Grand Rapids MI, Great Falls MT, Milwaukee WI, Missoula MT, Portland ME, Rapid City SD, Rochester NY, Sheridan WY, Sioux City IA, Syracuse NY

TABLE 5.4-26

Uof — BASE CASE; PERIMETER DAYLIGHTING: N/A, VLT ≥ SC

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	BASE CASE 0.68 to 0.46	BASE CASE 0.45 to 0.29	BASE CASE 0.28 to 0
0 - 1.50	0.000 - 0.249	1.000 - 0.71	20	27	32
		0.709 - 0.60	21	30	38
		0.599 - 0.50	21	31	44
		0.499 - 0.38	21	33	49
		0.379 - 0.25	22	35	57
		0.249 - 0.00	22	36	64
	0.250 - 0.499	1.000 - 0.71	21	31	41
		0.709 - 0.60	22	34	48
		0.599 - 0.50	22	35	54
		0.499 - 0.38	22	36	58
		0.379 - 0.00	22	36	64
	0.500 +	1.000 - 0.71	22	35	51
		0.709 - 0.60	23	36	57
		0.599 - 0.50	22	37	62
		0.499 - 0.00	22	37	65
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	19	24	27
		0.709 - 0.60	21	27	33
		0.599 - 0.50	22	30	38
		0.499 - 0.38	23	32	43
		0.379 - 0.25	24	36	52
		0.249 - 0.00	26	40	64
	0.250 - 0.499	1.000 - 0.71	22	29	36
		0.709 - 0.60	23	32	42
		0.599 - 0.50	24	34	47
		0.499 - 0.38	25	37	53
		0.379 - 0.00	26	39	61
	0.500 +	1.000 - 0.71	23	33	44
		0.709 - 0.60	25	36	51
		0.599 - 0.50	25	38	56
		0.499 - 0.00	26	40	62

OPAQUE WALL Uow

ILD 0 - 1.50:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.074	HC ≥ 5	20	0.076	0.096
	HC ≥ 10	20	0.082	0.10
	HC ≥ 15	20	0.087	0.11
	HC ≥ 5	65	0.077	0.098
	HC ≥ 10	65	0.084	0.11
	HC ≥ 15	65	0.089	0.11

ILD 1.51 - 3.00:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.074	HC ≥ 5	19	0.077	0.10
	HC ≥ 10	19	0.084	0.12
	HC ≥ 15	19	0.091	0.12
	HC ≥ 5	64	0.077	0.10
	HC ≥ 10	64	0.084	0.11
	HC ≥ 15	64	0.091	0.12

3.01 - 3.50	0.000 - 0.249	1.000 - 0.71	18	22	24
		0.709 - 0.60	20	25	30
		0.599 - 0.50	21	28	34
		0.499 - 0.38	22	31	40
		0.379 - 0.25	24	35	49
		0.249 - 0.00	26	39	61
	0.250 - 0.499	1.000 - 0.71	21	27	32
		0.709 - 0.60	22	30	38
		0.599 - 0.50	23	33	43
		0.499 - 0.38	24	35	49
		0.379 - 0.00	26	38	58
	0.500 +	1.000 - 0.71	23	31	40
		0.709 - 0.60	24	34	47
		0.599 - 0.50	25	36	52
		0.499 - 0.00	26	39	58

Daylight Sensing Controls

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.074	HC ≥ 5	18	0.077	0.10
	HC ≥ 10	18	0.086	0.12
	HC ≥ 15	18	0.093	0.13
	HC ≥ 5	61	0.077	0.10
	HC ≥ 10	61	0.085	0.12
	HC ≥ 15	61	0.092	0.12

	Min R-Value		
WALL BELOW GRADE:	10		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	18	15	11
Vertical	8	6	4

	Max Uo
ROOF:	0.049
WALL ADJACENT TO UNCOND SPACE:	0.12
FLOOR OVER UNCOND SPACE:	0.041

ALTERNATE COMPONENT PACKAGES FOR:

HDD50 = 4001 - 5000
CDD65 = 0 - 1150
VSEW = 560 - 845

Alpena MI, Bangor ME, Burlington VT, Cutbank MT, Eau Claire WI, Greenbay WI, Huron SD, Madison WI, Mason City IA, Massena NY, Miles City MT, Minneapolis MN, Pierre SD, Rochester NY, Sioux Falls SD

TABLE 5.4-26

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	Uof BASE CASE 0.68 to 0.46	Uof BASE CASE 0.45 to 0.29	Uof BASE CASE 0.28 to 0	PERIMETER DAYLIGHTING N/A	PERIMETER DAYLIGHTING VLT ≥ SC
0 - 1.50	0.000 - 0.249	1.000 - 0.71	19	26	31		
		0.709 - 0.60	21	29	37		
		0.599 - 0.50	21	31	42		
		0.499 - 0.38	22	33	48		
		0.379 - 0.25	22	35	55		
		0.249 - 0.00	22	36	62		
	0.250 - 0.499	1.000 - 0.71	21	31	40		
		0.709 - 0.60	22	33	47		
		0.599 - 0.50	22	34	52		
		0.499 - 0.38	22	35	56		
		0.379 - 0.00	23	36	62		
	0.500 +	1.000 - 0.71	22	34	49		
		0.709 - 0.60	23	36	55		
		0.599 - 0.50	23	36	59		
		0.499 - 0.00	23	37	63		
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	18	23	26		
		0.709 - 0.60	20	26	31		
		0.599 - 0.50	21	29	36		
		0.499 - 0.38	22	31	42		
		0.379 - 0.25	24	35	50		
		0.249 - 0.00	25	39	61		
	0.250 - 0.499	1.000 - 0.71	21	28	33		
		0.709 - 0.60	22	31	40		
		0.599 - 0.50	23	33	45		
		0.499 - 0.38	24	35	50		
		0.379 - 0.00	25	38	58		
	0.500 +	1.000 - 0.71	23	32	41		
		0.709 - 0.60	24	35	48		
		0.599 - 0.50	25	36	53		
		0.499 - 0.00	25	38	58		

OPAQUE WALL Uow

ILD 0 - 1.50:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.069	HC ≥ 5	19	0.070	0.085
	HC ≥ 10	19	0.074	0.094
	HC ≥ 15	19	0.078	0.096
	HC ≥ 5	63	0.071	0.087
	HC ≥ 10	63	0.075	0.096
	HC ≥ 15	63	0.079	0.099

ILD 1.51 - 3.00:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.069	HC ≥ 5	18	0.071	0.090
	HC ≥ 10	18	0.076	0.10
	HC ≥ 15	18	0.080	0.10
	HC ≥ 5	61	0.070	0.089
	HC ≥ 10	61	0.075	0.10
	HC ≥ 15	61	0.079	0.10

3.01 - 3.50

0.000 - 0.249	1.000 - 0.71	17	21	23
	0.709 - 0.60	19	24	29
	0.599 - 0.50	20	27	33
	0.499 - 0.38	22	30	38
	0.379 - 0.25	24	33	46
	0.249 - 0.00	26	38	58
0.250 - 0.499	1.000 - 0.71	20	26	30
	0.709 - 0.60	22	29	37
	0.599 - 0.50	23	31	41
	0.499 - 0.38	24	34	47
	0.379 - 0.00	25	37	55
0.500 +	1.000 - 0.71	22	30	38
	0.709 - 0.60	23	33	44
	0.599 - 0.50	24	35	50
	0.499 - 0.00	25	37	55

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.069	HC ≥ 5	17	0.071	0.092
	HC ≥ 10	17	0.077	0.10
	HC ≥ 15	17	0.082	0.10
	HC ≥ 5	58	0.070	0.091
	HC ≥ 10	58	0.076	0.10
	HC ≥ 15	58	0.080	0.10

Daylight Sensing Controls

	Min R-Value		
WALL BELOW GRADE:	11		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	18	15	11
Vertical	8	6	4

	Max Uo
ROOF:	0.045
WALL ADJACENT TO UNCOND SPACE:	0.11
FLOOR OVER UNCOND SPACE:	0.040

ALTERNATE COMPONENT PACKAGES FOR:

HDD50 = 3201 - 4000
CDD65 = 0 - 1150
VSEW = > 845

Casper WY
Cheyenne WY
Elko NV
Ely NV
North Platte NE

Pocatello ID
Scottsbluff NE

TABLE 5.4-27

OPAQUE WALL Uow (LIGHT WEIGHT WALL: Uow (HC<5); MASS WALL: HC RANGE, PCT FEN, INT INS, EXT INS)

Casper WY, Cheyenne WY, Elko NV, Ely NV, North Platte NE:

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.073	HC ≥ 5	19	0.076	0.10
	HC ≥ 10	19	0.085	0.12
	HC ≥ 15	19	0.092	0.12
	HC ≥ 5	63	0.078	0.10
	HC ≥ 10	63	0.086	0.12
	HC ≥ 15	63	0.095	0.13

Pocatello ID, Scottsbluff NE:

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.073	HC ≥ 5	18	0.077	0.11
	HC ≥ 10	18	0.088	0.13
	HC ≥ 15	18	0.098	0.14
	HC ≥ 5	67	0.078	0.10
	HC ≥ 10	67	0.087	0.12
	HC ≥ 15	67	0.098	0.13

Uof (BASE CASE and PERIMETER DAYLIGHTING; VLT ≥ SC applies to the 0.28 to 0 perimeter daylighting column)

Casper WY, Cheyenne WY, Elko NV, Ely NV, North Platte NE:

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	BASE CASE 0.68 to 0.46	BASE CASE 0.45 to 0.29	BASE CASE 0.28 to 0	PERIMETER DAYLIGHTING 0.68 to 0.46	PERIMETER DAYLIGHTING 0.45 to 0	PERIMETER DAYLIGHTING 0.28 to 0
0 - 1.50	0.000 - 0.249	1.000 - 0.71	19	26	30	19	26	32
		0.709 - 0.60	20	28	36	19	29	38
		0.599 - 0.50	20	30	41	19	30	43
		0.499 - 0.38	20	32	46	19	31	48
		0.379 - 0.25	20	33	53	19	32	54
		0.249 - 0.00	20	33	60	19	32	57
	0.250 - 0.499	1.000 - 0.71	21	31	39	20	31	42
		0.709 - 0.60	21	33	46	20	32	49
		0.599 - 0.50	21	34	51	20	33	53
		0.499 - 0.38	21	34	56	20	33	57
		0.379 - 0.00	21	34	61	20	33	60
	0.500 +	1.000 - 0.71	22	34	49	21	34	52
		0.709 - 0.60	22	35	55	20	34	58
		0.599 - 0.50	21	36	60	20	34	61
		0.499 - 0.00	21	36	63	20	34	62

Pocatello ID, Scottsbluff NE:

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	BASE CASE 0.68 to 0.46	BASE CASE 0.45 to 0.29	BASE CASE 0.28 to 0	PERIMETER DAYLIGHTING 0.68 to 0.46	PERIMETER DAYLIGHTING 0.45 to 0	PERIMETER DAYLIGHTING 0.28 to 0
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	18	22	24	20	27	32
		0.709 - 0.60	20	25	30	21	30	38
		0.599 - 0.50	21	28	34	22	32	44
		0.499 - 0.38	22	31	40	23	34	49
		0.379 - 0.25	23	34	48	23	36	57
		0.249 - 0.00	26	38	59	24	38	64
	0.250 - 0.499	1.000 - 0.71	21	27	32	22	32	42
		0.709 - 0.60	22	30	38	23	34	49
		0.599 - 0.50	23	33	43	23	36	55
		0.499 - 0.38	24	35	49	24	37	60
		0.379 - 0.00	25	38	57	24	38	65
	0.500 +	1.000 - 0.71	23	32	40	23	36	52
		0.709 - 0.60	24	35	47	24	37	59
		0.599 - 0.50	25	36	52	24	38	64
		0.499 - 0.00	25	38	58	24	39	67

3.01 - 3.50

0.000 - 0.249	1.000 - 0.71	16	19	21	20	26	31
	0.709 - 0.60	18	23	26	21	30	38
	0.599 - 0.50	20	25	30	22	32	43
	0.499 - 0.38	21	28	35	23	34	49
	0.379 - 0.25	23	32	43	24	36	57
	0.249 - 0.00	25	36	55	25	38	64
0.250 - 0.499	1.000 - 0.71	19	24	28	22	31	41
	0.709 - 0.60	21	28	34	23	34	48
	0.599 - 0.50	22	30	39	23	35	54
	0.499 - 0.38	23	33	44	24	37	59
	0.379 - 0.00	24	36	52	25	38	65
0.500 +	1.000 - 0.71	21	29	36	23	35	51
	0.709 - 0.60	23	32	42	24	37	58
	0.599 - 0.50	24	34	47	24	38	63
	0.499 - 0.00	24	36	53	25	39	66

Daylight Sensing Controls

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.073	HC ≥ 5	10	0.077	0.11
	HC ≥ 10	10	0.089	0.14
	HC ≥ 15	10	0.10	0.15
	HC ≥ 5	60	0.077	0.10
	HC ≥ 10	60	0.086	0.12
	HC ≥ 15	60	0.095	0.13

	Min R-Value		
WALL BELOW GRADE:	10		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	18	15	11
Vertical	8	6	4

	Max Uo
ROOF:	0.049
WALL ADJACENT TO UNCOND SPACE:	0.12
FLOOR OVER UNCOND SPACE:	0.042

ALTERNATE COMPONENT PACKAGES FOR:

HDD50 = 4001 - 5000
CDD65 = 0 - 1150
VSEW = > 845

Bryce UT
Eagle CO
Rock Springs WY

TABLE 5.4-28

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	BASE CASE Uof 0.68 to 0.46	BASE CASE Uof 0.45 to 0.29	BASE CASE Uof 0.28 to 0	PERIMETER DAYLIGHTING N/A	PERIMETER DAYLIGHTING VLT ≥ SC
0 - 1.50	0.000 - 0.249	1.000 - 0.71	16	30	40		
		0.709 - 0.60	14	29	47		
		0.599 - 0.50	13	27	51		
		0.499 - 0.38	11	24	53		
		0.379 - 0.25	10	20	51		
		0.249 - 0.00	8	16	40		
	0.250 - 0.499	1.000 - 0.71	15	31	51		
		0.709 - 0.60	13	28	56		
		0.599 - 0.50	11	25	57		
		0.499 - 0.38	10	22	56		
		0.379 - 0.00	9	18	48		
	0.500 +	1.000 - 0.71	13	30	59		
		0.709 - 0.60	11	25	60		
		0.599 - 0.50	10	22	58		
		0.499 - 0.00	9	19	53		
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	17	26	32		
		0.709 - 0.60	17	27	38		
		0.599 - 0.50	17	28	42		
		0.499 - 0.38	17	28	46		
		0.379 - 0.25	16	27	49		
		0.249 - 0.00	15	26	49		
	0.250 - 0.499	1.000 - 0.71	18	29	41		
		0.709 - 0.60	17	29	46		
		0.599 - 0.50	17	29	49		
		0.499 - 0.38	16	28	51		
		0.379 - 0.00	16	27	52		
	0.500 +	1.000 - 0.71	18	30	49		
		0.709 - 0.60	17	30	52		
		0.599 - 0.50	17	29	54		
		0.499 - 0.00	16	28	54		

OPAQUE WALL Uow (LIGHT WEIGHT WALL / MASS WALL)

ILD 0 - 1.50:

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.064	HC ≥ 5	10	0.065	0.086
	HC ≥ 10	10	0.070	0.10
	HC ≥ 15	10	0.075	0.10
	HC ≥ 5	60	0.066	0.10
	HC ≥ 10	60	0.074	0.12
	HC ≥ 15	60	0.083	0.13

ILD 1.51 - 3.00:

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.064	HC ≥ 5	17	0.066	0.093
	HC ≥ 10	17	0.072	0.11
	HC ≥ 15	17	0.079	0.11
	HC ≥ 5	54	0.066	0.094
	HC ≥ 10	54	0.073	0.11
	HC ≥ 15	54	0.080	0.12

3.01 - 3.50

0.000 - 0.249	1.000 - 0.71	17	24	29
	0.709 - 0.60	17	25	34
	0.599 - 0.50	17	26	38
	0.499 - 0.38	17	27	42
	0.379 - 0.25	17	27	46
	0.249 - 0.00	16	27	49
0.250 - 0.499	1.000 - 0.71	18	27	37
	0.709 - 0.60	18	28	42
	0.599 - 0.50	17	28	45
	0.499 - 0.38	17	28	48
	0.379 - 0.00	17	28	50
0.500 +	1.000 - 0.71	18	29	44
	0.709 - 0.60	18	29	48
	0.599 - 0.50	17	29	51
	0.499 - 0.00	17	29	52

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.064	HC ≥ 5	17	0.066	0.095
	HC ≥ 10	17	0.073	0.11
	HC ≥ 15	17	0.080	0.12
	HC ≥ 5	52	0.066	0.096
	HC ≥ 10	52	0.073	0.11
	HC ≥ 15	52	0.080	0.12

Daylight Sensing Controls

	Min R-Value		
WALL BELOW GRADE:	11		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	18	15	11
Vertical	8	6	4

	Max Uo
ROOF:	0.045
WALL ADJACENT TO UNCOND SPACE:	0.11
FLOOR OVER UNCOND SPACE:	0.040

ALTERNATE COMPONENT PACKAGES FOR:

HDD50 = 6001 - 6500
CDD65 = 0 - 1150
VSEW = 560 - 845

Bismarck ND
Caribou ME
Duluth MN
Fargo ND
Glasgow MT

International Falls MN
Minot ND
Sault Sainte Marie MI

TABLE 5.4-29

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	BASE CASE Uof 0.68 to 0.46	BASE CASE Uof 0.45 to 0.29	BASE CASE Uof 0.28 to 0	PERIMETER DAYLIGHTING N/A	PERIMETER DAYLIGHTING VLT ≥ SC
0 - 1.50	0.000 - 0.249	1.000 - 0.71	19	28	37		
		0.709 - 0.60	19	30	43		
		0.599 - 0.50	19	31	47		
		0.499 - 0.38	19	31	51		
		0.379 - 0.25	18	31	55		
		0.249 - 0.00	18	30	57		
	0.250 - 0.499	1.000 - 0.71	20	31	46		
		0.709 - 0.60	19	32	51		
		0.599 - 0.50	19	32	55		
		0.499 - 0.38	19	32	57		
		0.379 - 0.00	18	31	59		
	0.500 +	1.000 - 0.71	20	33	53		
		0.709 - 0.60	19	33	58		
		0.599 - 0.50	19	32	59		
		0.499 - 0.00	19	32	60		
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	18	25	31		
		0.709 - 0.60	19	28	38		
		0.599 - 0.50	20	29	41		
		0.499 - 0.38	20	31	46		
		0.379 - 0.25	21	33	52		
		0.249 - 0.00	21	34	58		
	0.250 - 0.499	1.000 - 0.71	20	29	39		
		0.709 - 0.60	21	31	45		
		0.599 - 0.50	21	32	49		
		0.499 - 0.38	21	33	53		
		0.379 - 0.00	21	34	58		
	0.500 +	1.000 - 0.71	21	32	46		
		0.709 - 0.60	21	33	52		
		0.599 - 0.50	21	34	55		
		0.499 - 0.00	22	34	58		

OPAQUE WALL Uow

ILD 0 - 1.50:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.064	HC ≥ 5	19	0.065	0.077
	HC ≥ 10	19	0.068	0.083
	HC ≥ 15	19	0.070	0.085
	HC ≥ 5	60	0.065	0.078
	HC ≥ 10	60	0.068	0.085
	HC ≥ 15	60	0.070	0.087

ILD 1.51 - 3.00:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.064	HC ≥ 5	18	0.065	0.081
	HC ≥ 10	18	0.069	0.090
	HC ≥ 15	18	0.072	0.093
	HC ≥ 5	58	0.065	0.081
	HC ≥ 10	58	0.068	0.089
	HC ≥ 15	58	0.072	0.092

3.01 - 3.50

0.000 - 0.249	1.000 - 0.71	18	24	28		
	0.709 - 0.60	19	27	34		
	0.599 - 0.50	20	29	39		
	0.499 - 0.38	21	30	44		
	0.379 - 0.25	21	33	50		
	0.249 - 0.00	22	35	58		
0.250 - 0.499	1.000 - 0.71	20	28	36		
	0.709 - 0.60	21	30	42		
	0.599 - 0.50	21	32	47		
	0.499 - 0.38	22	33	51		
	0.379 - 0.00	22	35	57		
0.500 +	1.000 - 0.71	21	31	44		
	0.709 - 0.60	22	33	50		
	0.599 - 0.50	22	34	53		
	0.499 - 0.00	22	36	57		

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.064	HC ≥ 5	10	0.065	0.083
	HC ≥ 10	10	0.069	0.092
	HC ≥ 15	10	0.073	0.096
	HC ≥ 5	50	0.065	0.082
	HC ≥ 10	50	0.069	0.091
	HC ≥ 15	50	0.072	0.094

Daylight Sensing Controls

	Min R-Value		
WALL BELOW GRADE:	12		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	10	15	11
Vertical	8	6	4

	Max Uo
ROOF:	0.041
WALL ADJACENT TO UNCOND SPACE:	0.10
FLOOR OVER UNCOND SPACE:	0.040

ALTERNATE COMPONENT PACKAGES FOR:

HDD50 = 1 - 6500
CDD65 = < 100
VSEW = < 500

Adak AK, Anchorage AK, Annette AK, Juneau AK, Kodiak AK — Yakutat AK

TABLE 5.4-30

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	BASE CASE Uof 0.60 to 0.46	BASE CASE Uof 0.45 to 0.29	BASE CASE Uof 0.28 to 0	PERIMETER DAYLIGHTING N/A	PERIMETER DAYLIGHTING VLT ≥ SC
0 - 1.50	0.000 - 0.249	1.000 - 0.71	17	29	45		
		0.709 - 0.60	16	29	50		
		0.599 - 0.50	15	28	53		
		0.499 - 0.38	14	27	55		
		0.379 - 0.25	13	25	53		
		0.249 - 0.00	12	22	48		
	0.250 - 0.499	1.000 - 0.71	16	30	53		
		0.709 - 0.60	15	28	56		
		0.599 - 0.50	14	27	57		
		0.499 - 0.38	14	25	56		
		0.379 - 0.00	13	23	52		
	0.500 +	1.000 - 0.71	15	29	58		
		0.709 - 0.60	14	27	58		
		0.599 - 0.50	14	25	57		
		0.499 - 0.00	13	24	54		
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	17	27	39		
		0.709 - 0.60	17	28	44		
		0.599 - 0.50	17	28	48		
		0.499 - 0.38	16	28	50		
		0.379 - 0.25	16	27	52		
		0.249 - 0.00	15	26	51		
	0.250 - 0.499	1.000 - 0.71	17	29	47		
		0.709 - 0.60	17	29	51		
		0.599 - 0.50	16	28	53		
		0.499 - 0.38	16	28	54		
		0.379 - 0.00	15	27	53		
	0.500 +	1.000 - 0.71	17	29	53		
		0.709 - 0.60	16	29	55		
		0.599 - 0.50	16	28	55		
		0.499 - 0.00	16	27	55		

OPAQUE WALL Uow

ILD 0 - 1.50:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.066	HC ≥ 5	17	0.066	0.071
	HC ≥ 10	17	0.069	0.075
	HC ≥ 15	17	0.071	0.076
	HC ≥ 5	50	0.067	0.073
	HC ≥ 10	50	0.069	0.078
	HC ≥ 15	50	0.072	0.080

ILD 1.51 - 3.00:

LIGHT WEIGHT WALL Uow (HC<5)	MASS WALL HC RANGE	PCT FEN	INT INS	EXT INS
0.066	HC ≥ 5	17	0.066	0.074
	HC ≥ 10	17	0.070	0.082
	HC ≥ 15	17	0.073	0.084
	HC ≥ 5	55	0.066	0.075
	HC ≥ 10	55	0.070	0.082
	HC ≥ 15	55	0.073	0.084

3.01 - 3.50

0.000 - 0.249	1.000 - 0.71	20	30	41
	0.709 - 0.60	20	31	47
	0.599 - 0.50	19	32	51
	0.499 - 0.38	19	32	55
	0.379 - 0.25	19	32	58
	0.249 - 0.00	18	31	59
0.250 - 0.499	1.000 - 0.71	20	32	50
	0.709 - 0.60	20	33	55
	0.599 - 0.50	19	33	58
	0.499 - 0.38	19	32	60
	0.379 - 0.00	19	32	61
0.500 +	1.000 - 0.71	20	33	57
	0.709 - 0.60	19	33	60
	0.599 - 0.50	19	33	62
	0.499 - 0.00	19	32	62

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.066	HC ≥ 5	20	0.066	0.076
	HC ≥ 10	20	0.070	0.084
	HC ≥ 15	20	0.073	0.087
	HC ≥ 5	62	0.066	0.076
	HC ≥ 10	62	0.070	0.084
	HC ≥ 15	62	0.074	0.087

Daylight Sensing Controls

	Min R-Value		
WALL BELOW GRADE:	12		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	18	15	11
Vertical	8	6	4

	Max Uo
ROOF:	0.041
WALL ADJACENT TO UNCOND SPACE:	0.10
FLOOR OVER UNCOND SPACE:	0.040

ALTERNATE COMPONENT PACKAGES FOR:

HDD50 = > 6500
CDD65 = < 100
VSEW = < 500

Bethel AK
Big Delta AK
Fairbanks AK
Gulkana AK
King Salmon AK

McGrath AK
Nome AK
Summit AK

TABLE 5.4-31

INTERNAL LOAD DENSITY (ILD) RANGE	PROJECTION FACTOR (PF)	SHADING COEFF RANGE (SCx)	BASE CASE Uof 0.68 to 0.46	BASE CASE Uof 0.45 to 0.29	BASE CASE Uof 0.28 to 0	PERIMETER DAYLIGHTING N/A	VLT ≥ SC
0 - 1.50	0.000 - 0.249	1.000 - 0.71	16	30	49		
		0.709 - 0.60	15	28	53		
		0.599 - 0.50	14	27	54		
		0.499 - 0.38	13	25	54		
		0.379 - 0.25	12	23	50		
		0.249 - 0.00	11	20	43		
	0.250 - 0.499	1.000 - 0.71	15	29	55		
		0.709 - 0.60	14	27	56		
		0.599 - 0.50	13	25	55		
		0.499 - 0.38	12	23	52		
		0.379 - 0.00	12	21	47		
	0.500 +	1.000 - 0.71	14	27	57		
		0.709 - 0.60	13	25	56		
		0.599 - 0.50	12	23	52		
		0.499 - 0.00	12	22	48		
1.51 - 3.00	0.000 - 0.249	1.000 - 0.71	17	27	41		
		0.709 - 0.60	16	27	46		
		0.599 - 0.50	16	27	48		
		0.499 - 0.38	15	26	49		
		0.379 - 0.25	15	25	49		
		0.249 - 0.00	14	24	46		
	0.250 - 0.499	1.000 - 0.71	16	28	48		
		0.709 - 0.60	16	27	50		
		0.599 - 0.50	15	26	51		
		0.499 - 0.38	15	26	50		
		0.379 - 0.00	14	24	48		
	0.500 +	1.000 - 0.71	16	27	51		
		0.709 - 0.60	15	26	52		
		0.599 - 0.50	15	26	51		
		0.499 - 0.00	14	25	50		

OPAQUE WALL Uow

ILD 0 - 1.50:

LIGHT WEIGHT WALL: Uow (HC<5)	MASS WALL: HC RANGE	PCT FEN	INT INS	EXT INS
0.053	HC ≥ 5	16	0.053	0.066
	HC ≥ 10	16	0.055	0.068
	HC ≥ 15	16	0.056	0.067
	HC ≥ 5	57	0.053	0.069
	HC ≥ 10	57	0.056	0.074
	HC ≥ 15	57	0.058	0.074

ILD 1.51 - 3.00:

LIGHT WEIGHT WALL: Uow (HC<5)	MASS WALL: HC RANGE	PCT FEN	INT INS	EXT INS
0.053	HC ≥ 5	17	0.053	0.068
	HC ≥ 10	17	0.055	0.072
	HC ≥ 15	17	0.057	0.072
	HC ≥ 5	52	0.053	0.069
	HC ≥ 10	52	0.056	0.074
	HC ≥ 15	52	0.057	0.073

3.01 - 3.50

0.000 - 0.249	1.000 - 0.71	18	29	42
	0.709 - 0.60	18	30	48
	0.599 - 0.50	18	30	51
	0.499 - 0.38	17	29	53
	0.379 - 0.25	17	29	54
	0.249 - 0.00	18	28	52
0.250 - 0.499	1.000 - 0.71	18	30	50
	0.709 - 0.60	18	30	53
	0.599 - 0.50	18	30	55
	0.499 - 0.38	17	29	55
	0.379 - 0.00	17	28	54
0.500 +	1.000 - 0.71	18	30	54
	0.709 - 0.60	18	30	56
	0.599 - 0.50	17	29	58
	0.499 - 0.00	17	29	55

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.053	HC ≥ 5	10	0.053	0.069
	HC ≥ 10	10	0.055	0.074
	HC ≥ 15	10	0.057	0.074
	HC ≥ 5	50	0.054	0.069
	HC ≥ 10	50	0.055	0.073
	HC ≥ 15	50	0.057	0.072

Daylight Sensing Controls

	Min R-Value		
WALL BELOW GRADE:	10		
UNHEATED SLAB ON GRADE:	24"	36"	48"
Horizontal	18	15	11
Vertical	8	6	4

	Max Uo
ROOF:	0.031
WALL ADJACENT TO UNCOND SPACE:	0.087
FLOOR OVER UNCOND SPACE:	0.040

Table 5.4-1
Climate Data Grouped by ACP Tables

ACP Table Number	HDD50 Range	CDD65 Range	VSEW Range	CDH80 Range	Example Cities
5.4-2	0	3001-4500	>800		Barbers Point, Hilo, Honolulu, Lihue
5.4-3	0	>4500	>845		Guantanamo Bay, Kwajalein, San Juan, Wake Island
5.4-4	1-1000	0-1150	560-845		Arcata, North Bend
5.4-5	1-1000	0- 300	>845		Oakland, San Francisco, Santa Maria, Sunnyville
5.4-6	1-1000	301-1150	>845		El Toro, Long Beach, Los Angeles, San Diego
5.4-7	1-1000	1151-2000	560-845		Atlanta, Augusta, Birmingham, Cherry Point, Greenville
5.4-8	1-1000	1151-2000	>845		Fresno, Red Bluff, Sacramento
5.4-9	1-1000	2001-3250	560-845		Charleston, Houston, Jackson, Montgomery, New Orleans
5.4-10	1-1000	2001-3250	>845	0-18000	Austin, Bakersfield, El Paso, Fort Worth, Tallahassee, Tampa
5.4-11	1-1000	2001-3250	>845	>18000	China Lake, Las Vegas, Tucson
5.4-12	1-1000	3251-4500	>845	0-18000	Brownsville, Corpus Christi, Miami, Orlando, West Palm Beach
5.4-13	1-1000	3251-4500	>845	>18000	Loredo, Phoenix, Yuma
5.4-14	1001-1750	0- 500	560-845		Olympia, Portland, Salem, Seattle/Tacoma, Whidbey Island
5.4-15	1001-1750	501-1150	560-845		Asheville, Medford
5.4-16	1001-1750	1-1150	>845		Prescott, Winslow, Yucca
5.4-17	1001-1750	1151-2000	560-845		Charlotte, Chattanooga, Knoxville, Norfolk, Raleigh, Richmond
5.4-18	1001-1750	1151-2000	>845		Albuquerque, Lubbock, Oklahoma City, Roswell, Tucumcari
5.4-19	1001-1750	2001-3250	560-845		Fort Smith, Memphis, Tulsa
5.4-20	1751-2600	0-1150	560-845		Baltimore, Boston, Columbus, Harrisburg, New York, Washington
5.4-21	2601-3200	0-1150	560-845		Akron, Chicago, Detroit, Hartford, Indianapolis, Pittsburgh
5.4-22	1751-3200	0-1150	>845		Boise, Colorado Springs, Denver, Reno, Salt Lake City
5.4-23	1751-3200	1151-2000	560-845		Evansville, Lexington, Louisville, Saint Louis, Springfield
5.4-24	1751-3200	1151-2000	>845		Dodge City, Grand Junction
5.4-25	3201-4000	0-1150	560-845		Albany, Buffalo, Concord, Des Moines, Milwaukee, Rapid City
5.4-26	4001-5000	0-1150	560-845		Bangor, Cutbank, Huron, Minneapolis, Rochester, Sioux Falls
5.4-27	3201-4000	0-1150	>845		Casper, Cheyenne, Ely, North Platte, Scottsbluff
5.4-28	4001-5000	0-1150	>845		Bryce, Eagle, Rock Springs
5.4-29	5001-6500	0-1150	560-845		Bismarck, Duluth, Fargo, Glasgow, International Falls
5.4-30	1-6500	< 100	<560		Adak, Anchorage, Juneau, Kodiak, Yakutat
5.4-31	>6500	< 100	<560		Bethel, Fairbanks, King Salmon, Nome, Summit

(b) From the list of cities in Appendix 5A, ''List of Cities and Climate Data'', which contains data for 234 cities, select the closest city climatologically to the building site. If the site is not one of the cities listed or if the climate at the site differs significantly from a listed adjacent city, obtain the information from the weather bureau or other reliable source and use (a) above. The column designated ''ACP Table No.'' contains the table number of the appropriate ACP Table.

(c) For information purposes only, the climate data used to develop the ACP tables for the above-grade wall section are shown in Table 5.4–32. The criteria for all other envelope sections was based on the most stringent level for the cities listed in the ACP Table.

5.4.3.2.2 Determination of Maximum Allowable Percent Fenestration.

(a) Using the appropriate ACP Table, determine the maximum allowable percent fenestration. The maximum allowable percent fenestration is the total area of fenestration assemblies divided by the total gross exterior wall area, considering all elevations of the building. Determining the maximum allowable percent fenestration requires the following five steps:

(1) Based on the Internal Load Density (ILD) for the proposed design, select one of the three Internal Load Ranges as the point of entry to the tables. Note for ILD's greater than 3.5 W/ft^2 use the 3.5 W/ft^2 range. For shell buildings, see procedures in Section 5.3.8. Determine the ILD of the proposed design, based on the sum of the Internal Lighting Power Allowance (ILPA), the Equipment Power Density (EPD) and Occupant Load Adjustment (OLA), as shown in Equation 5.4–1.

$$ILD=ILPA+EPD+OLA$$

Equation 5.4–1

Where:

The Internal Lighting Power Allowance (ILPA) shall be:

1. The building average Internal Lighting Power Allowance (ILPA) of the design building in W/ft^2 as determined in Section 3.4 or 3.5;

2. The average of the Lighting Power Budgets (LPB) for all activity areas within 15 ft of each exterior wall based on the procedures specified by the Systems Performance Criteria of Section 3.5.3, or

3. The actual lighting power density of the proposed design in W/ft^2, either the building average or the average of the lighting power within 15 ft of each exterior wall.

NOTE.— The lighting prescriptive path, Section 3.4, does not provide lighting values for health, assembly, multi-family high rise, and hotel/motel buildings type occupancies. Use the 1.51 to 3.0 range of Internal Load Density for health and assembly buildings; and the 0 to 1.5 range for multi-family high rise and hotel/motel buildings.

The Equipment Power Density (EPD) shall be either:

1. The building average receptacle power density selected from Table 5.4–33 in W/ft^2; or

Table 5.4-33
Average Receptacle Power Densities

BUILDING TYPE	W/ft^2
1. Assembly	0.25
2. Office	0.75
3. Retail	0.25
4. Warehouse	0.10
5. School	0.50
6. Hotel/Motel	0.25
7. Restaurant	0.10
8. Health	1.00
9. Multi-Family	0.75

2. The actual average receptacle power density for all activity areas within 15 ft of each exterior wall in W/ft^2, considering diversity. For determining compliance in Tables 5.4–2 through 5.4–31, the actual average receptacle power densities calculated by this method that exceed 1.0 W/ft^2 shall be limited to 1.0 W/ft^2 in Equation 5.4–1.

The Occupant Load Adjustment (OLA) shall be either:

1. 0.0 W/ft^2. This recognizes the assumed occupant sensible load of 0.6 W/ft^2 that is built into the ACP tables; or

2. A positive or negative difference between the actual occupant load and 0.6 W/ft^2 if the design building has a larger or smaller occupant load.

(2) *Select external shading projection factor (PF).* If no external shading projections are used in the proposed design, select the column designated Projection Factor=0.000−0.249. If external shading projections are used, determine the average area weighted projection factor on the window in accordance with Equation 5.4–2. Then select the appropriate column in the ACP Table.

$$PF = P_d/H$$

Equation 5.4–2

Where:

PF=Average area weighted projection factor

P_d=External horizontal shading projection depth, in. or ft

H=Sum of height of the fenestration and the distance from the top of the fenestration to the bottom of external shading projection in units consistent with P_d.

(3) Select the Shading Coefficient of the fenestration (SC_x) including internal, integral, and external shading devices, but excluding the effect of external shading projections (PF). This includes curtains, shades, or blinds. Reference *ASHRAE Handbook, 1985 Fundamentals Volume,* Chapter 27.

(4) Select one of the daylighting options, either:

1. Base Case, no daylighting; or

2. Perimeter Daylighting (automatic daylight controls for lighting system must be used). This option is not available in some locations.

(5) Select appropriate fenestration type. For most options, this is determined by the thermal transmittance value (U_{of}) of the fenestration assembly. For some fenestration options, the visible light transmittance (VLT) of the fenestration should not be less than the shading coefficient of the glazed portion of the fenestration assembly, not considering any shading devices. The ranges generally correspond to single glazing, double glazing, triple glazing and high performance glazing incorporating low emissivity coatings/films or more than two glazing layers. Each ACP table includes at most, three ranges of glazing U-value.

5.4.4.2.3 *Determine the Maximum U_{ow} for the Opaque Wall Assembly*. In the appropriate ACP Table the Maximum U_{ow} for the opaque wall assembly is determined using the following steps:

(a) For a lightweight wall assembly, heat capacity (HC) less than 5 Btu/ft^2•°F, use the value indicated. This U_{ow} is constant over all internal load ranges.

(b) To use the mass wall adjustment, the following additional steps are necessary:

(1) Select the same internal load range as that used in determining the maximum allowable percent fenestration.

(2) Select the mass wall heat capacity (HC) and insulation position. If the wall insulation is positioned internal to or integral with the wall mass, use the column headed Interior/Integral Insulation. If the wall insulation is positioned external to the wall mass use the column headed Exterior Insulation. For HC less than 5 Btu/ft^2•°F this adjustment table cannot be used. At this step you will have two choices of U_{ow} that are keyed to a small or large percent fenestration. This represents the full range of U_{ow} values allowed.

(3) Select or interpolate the appropriate maximum U_{ow} for the opaque wall based on the maximum allowable percent fenestration determined in Section 5.4.4.2.2 or the actual building percent fenestration whichever value is lower. The U_{ow} shall be determined by straight line interpolation for fenestration percentages between the smallest and largest values listed. If the design building percentage fenestration is less than the smallest value listed, select the U_{ow} for the largest percentage fenestration listed.

5.4.4.2.4 *Determine Other Envelope Criteria*. In each ACP table, the criteria for roof, wall adjacent to unconditioned space, wall below grade (first story only), floor over unconditioned space, and slab-on-grade floors, shall be met. For heated slabs on grade, the R-value shall be the R-value for the unheated slab-on-grade plus 2.0. For skylights, the daylight credit procedure presented in Section 5.3.10 shall be used.

5.5 Building Envelope—System Performance Compliance Alternative

5.5.1 Roof Thermal Transmittance Criteria

5.5.1.1 Any building that is heated and/or mechanically cooled shall have an overall thermal transmittance value (U_{or}) for the gross area of the roof assembly not greater than the value determined by Equation 5.5–1. The provisions of Section 5.3 shall be followed in determining acceptable combinations of materials that will meet the required U_{or} values of Equation

5.5–1.

$$U_o=1/(5.3+1.8\times10^{-3}\times HDD65+1.3\times10^{-3}\times CDD65+2.6\times10^{-4}\times CDH80)$$

Equation 5.5–1

5.5.1.2 Equation 5.5–1 applies only for climate locations with HDD65 less than or equal to 15,000. For climate locations with HDD65 greater than 15,000, see subsection 5.3.9, Table 5.3–5.

5.5.1.2.1 *Exceptions to Section 5.5.1.2:*

(a) any building that is only heated shall have an overall thermal transmittance value (U_{or}) for the gross area of the roof assembly less than or equal to the value determined by Equation 5.5–1 with CDD65 and CDH80 set equal to zero; and

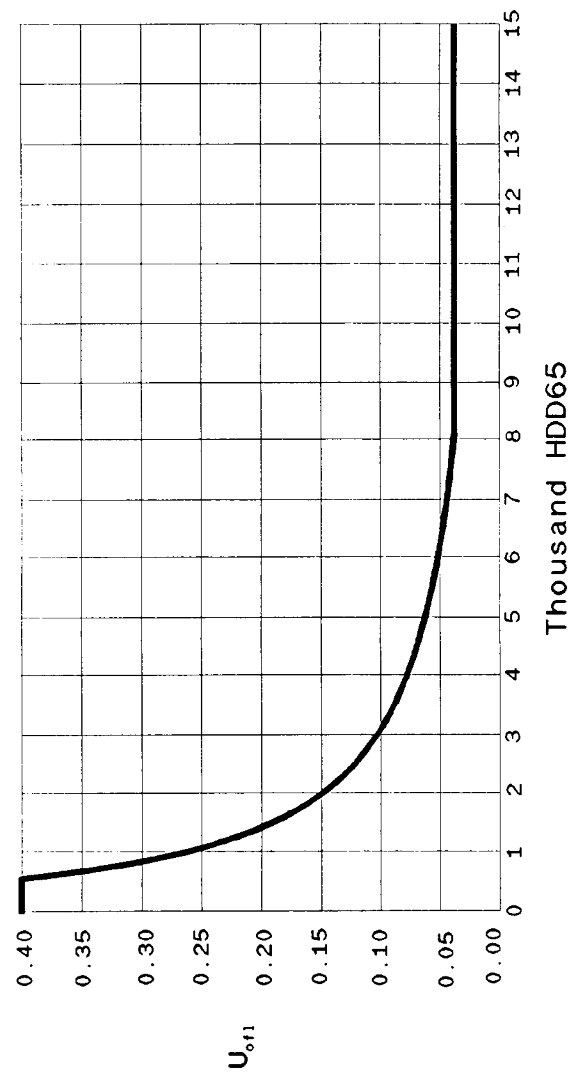
(b) any building that is only mechanically cooled shall have an overall thermal transmittance value (U_{or}) for the gross area of the roof assembly less than or equal to the value determined by Equation 5.5–1 with HDD65 set equal to zero.

5.5.2 Floor Thermal Transmittance Criteria

5.5.2.1 The floors of any building that is heated and/or mechanically cooled shall meet the following thermal criteria:

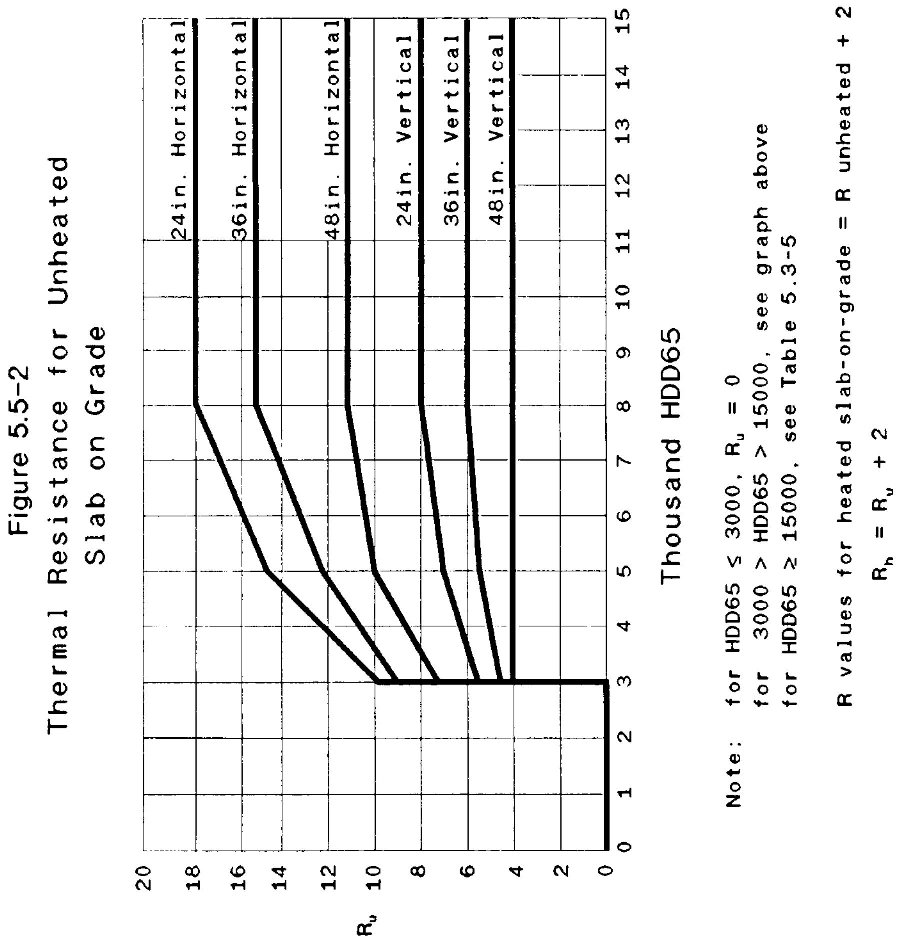
5.5.2.1.1 Floors of conditioned spaces over unconditioned spaces shall have a thermal transmittance (U_{of}) not greater than that specified in Figure 5.5–1.

Figure 5.5–1
Maximum Overall Thermal Transmittance for Floors of Conditioned Spaces Over Unconditioned Spaces



Note:
for HDD65 ≤ 550, U_{ofl} = 0.40
for 550 < HDD65 ≤ 8000, U_{ofl} = 1/[0.840 + 0.00302 × HDD65]
for 8000 < HDD65 < 15000, U_{ofl} = 0.04
for HDD65 ≥ 15000, see Table 5.3-5

5.5.2.1.2 Slab-on-grade floors shall have insulation around the perimeter of the floor with the thermal resistance (R_u) of the insulation as specified in Figure 5.5–2. The insulation specified in Figure 5.5–2 shall extend either in a vertical plane downward from the top of the slab for the minimum distance shown or downward to the bottom of the slab for the minimum distance shown then in a horizontal plane beneath the slab. The horizontal length, or vertical depth, of insulation required varies from 24 in. to 48 in. depending upon the R-value selected. For heated slabs, an R of 2 shall be added to the thermal resistance required in Figure 5.5–2.

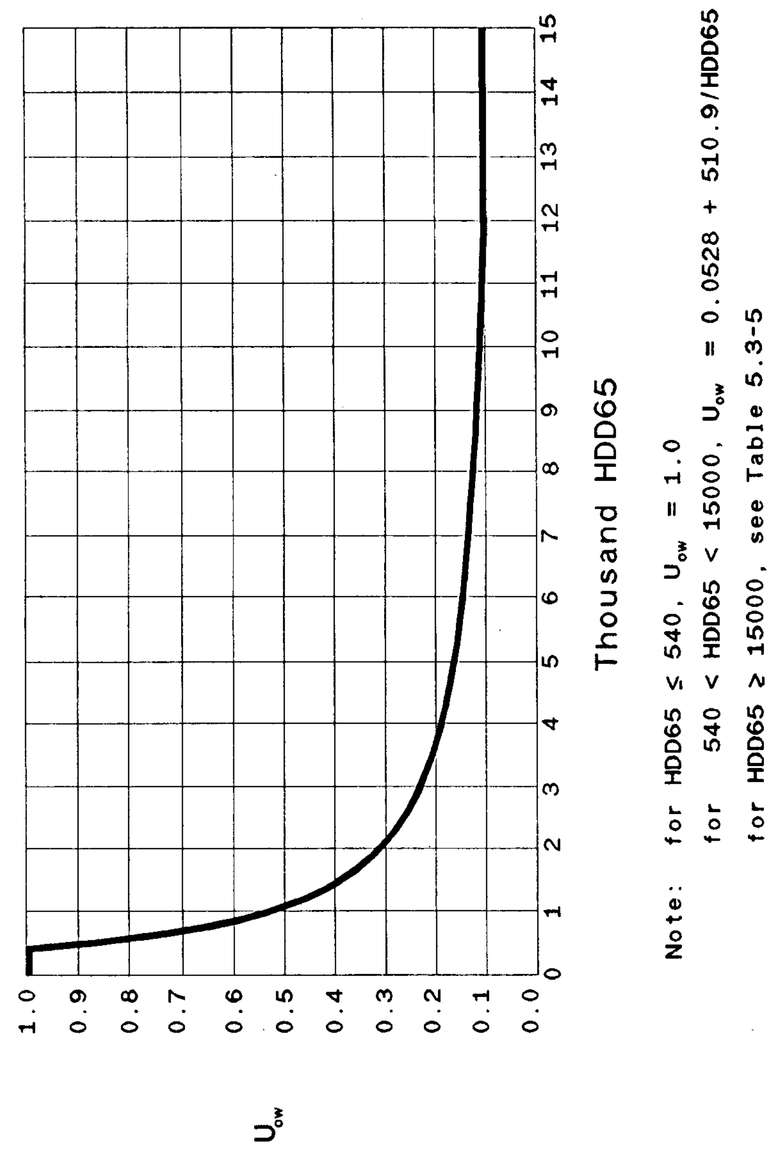


(a) Vertical insulation is not required to extend below the foundation footing. There are no insulation requirements for slabs in locations having less than 3,000 HDD65 for footings extending less than 18 in. below grade.

5.5.3 Thermal Transmittance Criteria For Opaque Walls Enclosing Conditioned Spaces Exposed to Interior Unconditioned Spaces

5.5.3.1 All opaque walls enclosing conditioned spaces exposed to interior unconditioned spaces shall have an overall thermal transmittance (U_{ow}) not greater than the value specified in Figure 5.5–3.

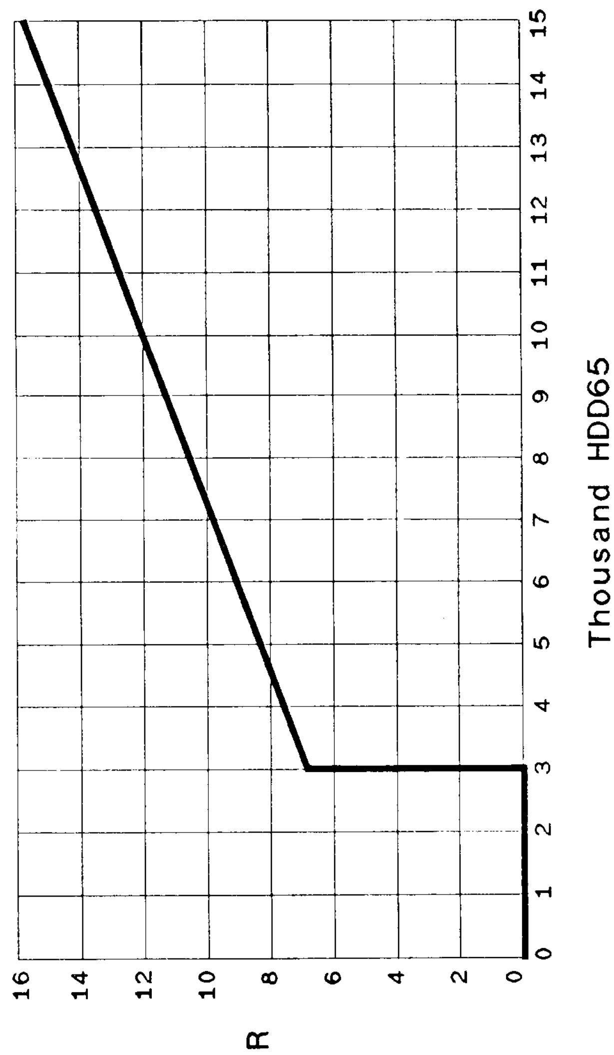
Figure 5.5–3
Maximum Overall Thermal Transmittance of Opaque Wall Sections With HC < 7



5.5.4 Thermal Resistance Criteria for Exterior Wall Insulation Below Grade

5.5.4.1 The thermal resistance (R) of the wall assembly shall be greater than, or equal to the insulation level specified in Figure 5.5–4, or the heat loss calculated in accordance with Chapter 25 of the *ASHRAE Handbook, 1985 Fundamentals Volume* shall be less than, or equal to that of a wall below grade having a thermal resistance equal to that specified in Figure 5.5–4. No insulation is required for climate locations with less than 3,000 HDD65 for those portions of walls more than one story below grade.

Figure 5.5–4
Thermal Resistance of Wall
First Story Below Grade



Note: for HDD65 ≤ 3000, R = 0
for 3000 < HDD65 < 15000, R = 4.5 + 0.00075 x HDD65
for HDD65 ≥ 15000, see Table 5.3-5

5.5.5 External Wall Criteria for Heating and Cooling

5.5.5.1 The external wall heating criteria (WC_h) and cooling criteria (WC_c) represent limits on cumulative annual heating and cooling energy flux attributable to transmission and solar gain. These limits accommodate variation in internal load and wall heat capacity. They shall be determined for a building envelope design using Equations 5.5–2 and 5.5–6 in Attachment 5B, ‘‘Equations to Determine External Wall Heating and Cooling Criteria (WC_c and WC_h) and to Determine Compliance (C_i and H_i) With the Criteria.''

5.5.6 Wall Heating and Cooling Compliance Values

5.5.6.1 The wall heating compliance value H_i and the wall cooling compliance value C_i are estimates of the cumulative annual heating and cooling energy flux attributable to heat transmission and solar gains. These estimates consider the effects of variations in internal load and wall heat capacity. They shall be calculated using Equations 5.5–2 and 5.5–6 in Attachment 5B.

5.5.6.3 Applying the Criteria

5.5.6.3.1 The wall criteria shall be applied as follows:

(a) For all buildings that are heated and mechanically cooled, the sum of the calculated wall heating and cooling compliance values, H_i and C_i, for all orientations of the proposed design, as determined in section 5.5.6, shall not exceed the sum of the corresponding wall criteria for all orientations for wall heating (WC_h) and wall cooling (WC_c).

(b) For buildings that are only heated, the sum of the calculated wall heating compliance values, H_i, for all orientations of the proposed design, as determined in section 5.5.6, shall not exceed the sum of the corresponding wall heating criterion WC_h for all orientations.

(c) For buildings that are only mechanically cooled, the sum of the calculated cooling compliance values, C_i, for all orientations of the proposed design, as determined from section 5.5.6, shall not exceed the sum of the corresponding wall cooling criteria, WC_c for all orientations.

5.5.6.4 Constraints on Thermal Transmittance Values

5.5.6.4.1 The compliance calculation procedure in section 5.5.6.3 allows great flexibility in selecting values for envelope components as long as the overall criteria are met. In calculating compliance, two constraints are imposed on thermal transmittance values for opaque wall assemblies and fenestration assemblies comprising the U_o term, as follows:

(a) *Opaque Wall Assemblies:* The opaque portion of walls with heat capacity (HC) less than 7 Btu/ft²÷°F shall have an overall thermal transmittance (U_{ow}) not greater than the value specified in Figure 5.5–4. Procedures, specified in section 5.3, shall be used to determine acceptable combinations of materials that meet the required value.

(b) *Fenestration Assemblies:* The overall thermal transmittance (U_{of}) of fenestration assemblies shall not exceed 0.81 Btu/h•ft²•°F for all locations with more than 3000 HDD65 if the fenestration area exceeds 10% of the total wall area exposed to the outside air. Thermal transmittance for the fenestration shall be determined using the calculation procedures in Section 5.3.1 and shall include the effects of sash, frames, edge effects, and spacers for multiple-glazed units.

5.5.6.5 Constraint on Daylighting Credit

5.5.6.5.1 For a given orientation, daylight credit may be used in Equations 5.5–2 and 5.5–6 only for that portion of the fenestration that is less than or equal to 65% of the gross wall area of the orientation.

5.5.6.6 Lighting Power Density

5.5.6.6.1 The Lighting Power Density used in calculating the compliance value shall be:

(a) The building average unit Interior Lighting Power Allowance of the proposed design in W/ft² as specified in section 3.0;

(b) The average of the Lighting Power Budgets for all activity areas within 15 ft of each exterior wall based on the procedures set forth in section 5.3; or

(c) The actual lighting power density of the proposed design in W/ft², either building average or average of the lighting power within 15 ft of each exterior wall.

5.5.6.7 Equipment Power Density

5.5.6.7.1 The equipment power density used in determining compliance shall be either:

(a) The "Average Receptacle Power Densities" from Table 5.4–32, or

(b) The actual average Equipment Unit Power Density, considering diversity, either building average or average in the activity areas within 15 ft of each exterior wall, not to exceed 1 W/ft².

5.5.6.8 Occupancy Loads

5.5.6.8.1 An occupancy load of 0.6 W/ft² is assumed. If the occupancy loads in the building design are different from this value, use the larger value.

Attachment 5A
List of Cities and Climate Data

NO	CITY	STATE	HDD50	HDD65	VSN	VSEW	VSS	CDD50	CDD65	CDH80	DR	NO HRS T<55	8AM-4PM 55≤T≤69	ACP TABLE
Alabama														
28	Birmingham	AL	765	2882	464	789	908	5182	1825	6272	17.5	720	760	5.4- 7
143	Mobile	AL	164	1580	486	816	919	6478	2419	7479	16.6	408	774	5.4- 9
145	Montgomery	AL	491	2261	462	823	981	5821	2116	8473	19.5	609	734	5.4- 9
Alaska														
2	Adak	AK	3562	8913	280	434	652	124	0	0	9.9	2754	156	5.4-30
9	Anchorage	AK	5301	10540	272	538	926	236	0	0	13.8	2398	521	5.4-30
10	Annette Island	AK	2545	7277	285	482	739	756	12	0	10.1	2169	719	5.4-30
24	Bethel	AK	8285	13449	252	453	789	312	0	0	14.3	2555	347	5.4-31
25	Big Delta	AK	9355	14069	249	527	989	777	16	25	19.0	2141	606	5.4-31
76	Fairbanks	AK	9841	14414	241	492	919	922	19	8	18.2	2083	682	5.4-31
93	Gulkana	AK	8865	13846	257	522	943	498	4	6	18.5	2225	615	5.4-31
105	Juneau	AK	4223	9350	254	410	642	348	0	0	12.7	2367	540	5.4-30
106	King Salmon	AK	6843	11992	270	499	860	330	4	6	15.4	2395	502	5.4-31
109	Kodiak	AK	3775	8896	276	509	852	360	6	0	10.6	2519	384	5.4-30
132	McGrath	AK	9967	14868	246	467	841	578	3	0	15.9	2265	596	5.4-31
152	Nome	AK	9061	14418	242	478	871	119	0	0	9.0	2710	210	5.4-31
208	Summit	AK	9210	14530	247	488	893	155	0	0	13.6	2616	298	5.4-31
231	Yakutat	AK	4486	9714	247	402	650	248	0	0	9.3	2471	439	5.4-30
Arizona														
163	Phoenix	AZ	90	1382	488	1116	1310	7830	3647	34521	21.2	373	746	5.4-13
171	Prescott	AZ	1477	4462	473	1090	1334	3385	895	3973	24.0	1021	725	5.4-16
218	Tucson	AZ	178	1601	500	1112	1280	6822	2769	19657	21.9	399	716	5.4-11
229	Winslow	AZ	1695	4603	471	1092	1338	3708	1141	7347	27.7	1130	634	5.4-16
234	Yuma	AZ	43	782	493	1151	1330	8921	4186	37892	23.5	247	697	5.4-13
Arkansas														
79	Fort Smith	AR	1149	3394	462	842	1005	5307	2077	10413	22.4	925	547	5.4-19
121	Little Rock	AR	912	3091	465	831	981	5351	2055	8450	17.5	865	626	5.4- 9
California														
12	Arcata	CA	582	5020	407	724	926	1038	1	0	8.9	1396	1509	5.4- 4
19	Bakersfield	CA	305	2194	474	1053	1211	5879	2294	15447	28.9	645	848	5.4-10
48	China Lake	CA	409	2444	468	1091	1312	6222	2782	26739	27.4	582	772	5.4-11
58	Daggett	CA	237	1916	475	1102	1309	6516	2720	22302	27.0	472	841	5.4-11
71	El Toro	CA	32	1577	486	977	1163	4764	834	2391	22.3	215	1474	5.4- 6
82	Fresno	CA	492	2700	459	1029	1199	5070	1803	13085	31.8	780	785	5.4- 8
122	Long Beach	CA	54	1483	482	956	1144	4947	900	1616	16.1	263	1502	5.4- 6
123	Los Angeles	CA	3	1494	482	962	1146	4456	472	136	14.1	145	1849	5.4- 6
146	Mount Shasta	CA	1947	5583	419	909	1153	2395	556	2073	16.2	1544	756	5.4-22
156	Oakland	CA	157	2922	453	909	1102	2792	82	23	16.4	770	1905	5.4- 5
167	Point Mugu	CA	8	2193	477	936	1131	3435	145	70	12.3	209	2146	5.4- 5
176	Red Bluff	CA	589	2884	428	951	1177	5110	1930	14404	29.5	860	810	5.4- 8
185	Sacramento	CA	381	2753	444	987	1185	4274	1171	7315	34.6	834	990	5.4- 8
191	San Diego	CA	2	1275	490	950	1121	4865	662	383	11.5	102	1911	5.4- 6
192	San Francisco	CA	186	3238	454	941	1146	2496	73	204	20.2	782	1796	5.4- 5
194	Santa Maria	CA	138	3041	476	950	1128	2663	92	513	20.9	414	2016	5.4- 5
209	Sunnyville	CA	142	2708	456	947	1145	3112	204	421	16.9	610	1794	5.4- 5
Colorado														
50	Colorado Springs	CO	2587	5996	435	976	1321	2557	491	2075	24.0	1357	725	5.4-22
62	Denver	CO	2652	6083	428	971	1321	2611	567	2934	25.5	1329	739	5.4-22
68	Eagle	CO	4232	8317	432	976	1296	1480	90	1008	35.4	1650	660	5.4-28
86	Grand Junction	CO	2616	5701	438	1003	1303	3611	1221	6147	27.4	1383	518	5.4-24
173	Pueblo	CO	2223	5285	442	992	1309	3384	971	5899	27.5	1077	720	5.4-22
Connecticut														
95	Hartford	CT	2953	6277	384	646	834	2857	706	2197	23.7	1459	598	5.4-21
Delaware														
227	Wilmington	DE	2133	5084	414	726	921	3602	1078	2188	17.2	1289	617	5.4-20

C.1

NO	CITY	STATE	HDD50	HDD65	VSN	VSEW	VSS	CDD50	CDD65	CDH80	DR	NO HRS T<55	8AM-4PM 55≤T≤69	ACP TABLE
District of Columbia														
223	Washington	DC	2004	4828	419	724	905	3734	1083	3592	18.6	1205	657	5.4-20
Florida														
11	Apalachicola	FL	163	1366	508	887	971	6967	2695	8289	14.3	322	778	5.4-10
60	Daytona	FL	81	787	503	860	953	7404	2635	5252	14.8	177	641	5.4-10
104	Jacksonville	FL	206	1357	495	849	943	7045	2721	7488	16.4	354	674	5.4-10
136	Miami	FL	3	185	527	874	936	9338	4045	9166	12.4	55	259	5.4-12
160	Orlando	FL	33	532	511	881	974	8288	3312	9757	17.1	131	571	5.4-12
211	Tallahassee	FL	307	1721	495	845	944	6462	2401	7323	16.1	421	747	5.4-10
212	Tampa	FL	37	575	518	890	974	7985	3047	8905	14.9	147	592	5.4-10
224	West Palm Beach	FL	0	177	519	846	906	9203	3904	10324	13.1	22	308	5.4-12
Georgia														
15	Atlanta	GA	866	3070	467	807	930	4837	1566	3799	17.6	915	749	5.4- 7
16	Augusta	GA	664	2584	468	803	933	5458	1904	6904	21.3	690	774	5.4- 7
128	Macon	GA	514	2330	476	822	939	5769	2111	8097	18.7	667	787	5.4- 9
196	Savannah	GA	410	1967	474	805	926	6112	2194	6308	16.6	529	725	5.4- 9
Hawaii														
22	Barbers Point	HI	0	3	592	978	965	9314	3842	3617	11.2	1	97	5.4- 2
97	Hilo	HI	0	0	557	817	805	8494	3019	1112	11.0	0	153	5.4- 2
98	Honolulu	HI	0	0	588	953	932	9625	4150	4537	9.8	0	69	5.4- 2
120	Lihue	HI	0	2	567	895	893	9219	3746	1912	9.6	0	140	5.4- 2
Idaho														
30	Boise	ID	2276	5667	399	916	1228	2828	744	4512	28.9	1542	647	5.4-22
117	Lewiston	ID	2015	5426	370	729	988	2709	645	4121	29.7	1467	748	5.4-20
166	Pocatello	ID	3404	7075	405	935	1262	2330	526	3293	32.8	1681	546	5.4-27
Illinois														
47	Chicago	IL	3000	6151	402	729	936	3339	1015	3190	16.6	1426	613	5.4-21
144	Moline	IL	3085	6250	405	736	959	3204	894	2808	19.5	1357	640	5.4-21
207	Springfield	IL	2490	5448	422	768	962	3675	1158	4038	20.2	1260	600	5.4-23
Indiana														
75	Evansville	IN	1948	4625	426	736	890	4063	1265	4288	18.4	1141	611	5.4-23
80	Fort Wayne	IN	3023	6145	395	664	826	3096	743	1629	17.7	1400	601	5.4-21
101	Indianapolis	IN	2624	5620	407	692	851	3430	951	2263	18.0	1375	602	5.4-21
204	South Bend	IN	3038	6280	396	690	857	2917	684	1840	21.1	1415	635	5.4-21
Iowa														
35	Burlington	IA	3009	6094	419	802	1030	3393	1002	2598	17.1	1354	649	5.4-21
63	Des Moines	IA	3275	6447	413	788	1027	3116	812	2383	17.5	1423	667	5.4-25
130	Mason City	IA	4311	7735	400	783	1053	2708	658	1882	20.8	1548	610	5.4-26
202	Sioux City	IA	3608	6750	406	794	1064	3326	993	3488	18.6	1438	602	5.4-25
Kansas														
66	Dodge City	KS	2280	5131	450	942	1196	4008	1384	7186	26.0	1252	637	5.4-24
84	Goodland	KS	2757	6090	434	935	1228	3047	905	5147	26.3	1358	625	5.4-22
215	Topeka	KS	2458	5201	434	837	1068	4120	1388	5212	22.3	1192	608	5.4-23
Kentucky														
56	Covington	KY	2154	5030	408	687	843	3656	1057	2638	18.3	1316	661	5.4-20
119	Lexington	KY	1921	4649	425	729	872	3904	1157	2853	15.6	1211	618	5.4-23
124	Louisville	KY	1851	4539	424	727	883	4144	1357	4716	17.6	1192	636	5.4-23
Louisiana														
23	Baton Rouge	LA	237	1573	488	806	889	6682	2543	8814	17.2	440	677	5.4- 9
113	Lake Charles	LA	214	1455	489	795	864	6849	2615	7883	14.8	396	668	5.4- 9
148	New Orleans	LA	179	1392	497	838	923	6840	2578	7380	15.1	324	789	5.4- 9
201	Shreveport	LA	447	2265	484	843	954	6022	2365	10039	18.1	687	697	5.4- 9
Maine														
21	Bangor	ME	4132	7998	378	693	950	1853	243	454	21.5	1721	669	5.4-26
38	Caribou	ME	5297	9483	357	649	922	1410	121	203	18.1	1862	692	5.4-29
169	Portland	ME	3531	7305	376	643	856	1946	245	399	19.6	1604	665	5.4-25

C.2

NO	CITY	STATE	HDD50	HDD65	VSN	VSEW	VSS	CDD50	CDD65	CDH80	DR	NO HRS T<55	8AM-4PM 55≤T≤69	ACP TABLE
Maryland														
20	Baltimore	MD	2020	4946	419	739	932	3683	1134	3825	18.6	1268	593	5.4-20
161	Patuxent	MD	1418	4002	429	758	943	4180	1289	2966	12.9	1118	729	5.4-17
Massachusetts														
31	Boston	MA	2416	5775	387	659	849	2810	695	1601	16.5	1495	713	5.4-20
Michigan														
7	Alpena	MI	4282	8164	371	661	862	1928	335	894	17.3	1707	695	5.4-26
64	Detroit	MI	2799	5997	390	676	858	3199	922	2238	18.8	1404	632	5.4-21
78	Flint	MI	3471	6917	379	641	811	2502	473	921	18.1	1563	634	5.4-25
87	Grand Rapids	MI	3392	6777	390	688	872	2680	590	1461	22.2	1562	622	5.4-25
195	Sault Sainte Marie	MI	5087	9282	359	640	858	1399	119	246	21.0	1838	733	5.4-29
216	Traverse City	MI	3934	7654	369	642	818	2193	438	1124	21.0	1651	679	5.4-25
Minnesota														
67	Duluth	MN	5797	9918	355	633	886	1511	157	258	20.0	1882	650	5.4-29
102	International Falls	MN	6414	10535	351	669	962	1473	119	167	22.0	1870	656	5.4-29
140	Minneapolis	MN	4563	8060	380	709	972	2751	773	2509	20.7	1620	566	5.4-26
181	Rochester	MN	4544	8100	383	691	927	2360	442	590	18.8	1584	652	5.4-26
Mississippi														
103	Jackson	MS	546	2424	481	833	942	5927	2330	8789	17.2	646	640	5.4- 9
135	Meridian	MS	546	2446	480	811	905	5723	2148	9508	20.2	613	719	5.4- 9
Missouri														
51	Columbia	MO	2225	4994	431	790	972	3940	1234	4242	21.5	1189	633	5.4-23
186	Saint Louis	MO	2111	4860	432	797	983	4193	1467	5379	18.7	1124	614	5.4-23
206	Springfield	MO	1839	4509	446	812	982	4115	1311	4170	20.4	1215	544	5.4-23
Montana														
26	Billings	MT	3627	7156	380	814	1160	2544	598	2695	25.6	1650	617	5.4-25
57	Cutbank	MT	4718	8941	357	768	1150	1368	117	702	27.6	1834	672	5.4-26
65	Dillon	MT	4140	8210	386	838	1187	1564	159	784	28.6	1814	639	5.4-26
83	Glasgow	MT	5082	8828	361	752	1115	2272	543	2642	26.0	1688	570	5.4-29
88	Great Falls	MT	3728	7454	366	776	1133	2199	450	1886	26.7	1684	641	5.4-25
96	Helena	MT	3926	7817	372	771	1098	1911	328	1771	28.3	1784	651	5.4-25
118	Lewistown	MT	4027	8089	368	753	1084	1629	216	1270	29.8	1740	673	5.4-26
138	Miles City	MT	4435	7989	374	800	1156	2694	773	4364	26.9	1588	565	5.4-26
142	Missoula	MT	3492	7560	363	704	957	1629	221	1513	30.8	1843	658	5.4-25
Nebraska														
85	Grand Island	NE	3315	6477	420	843	1115	3309	996	4580	24.5	1431	611	5.4-25
155	North Platte	NE	3447	6905	419	880	1183	2731	715	3468	26.2	1514	592	5.4-27
159	Omaha	NE	2981	5968	414	806	1066	3618	1130	3883	19.6	1355	586	5.4-21
197	Scottsbluff	NE	3335	6900	413	861	1168	2603	693	3745	28.3	1457	620	5.4-27
Nevada														
72	Elko	NV	3345	7178	420	1000	1332	1997	355	4065	37.8	1540	569	5.4-27
73	Ely	NV	3683	7666	432	1014	1350	1650	157	1317	30.1	1529	683	5.4-27
116	Las Vegas	NV	449	2399	456	1136	1417	6567	3043	26408	25.5	604	719	5.4-11
125	Lovelock	NV	2438	5845	418	1094	1452	2813	745	6659	34.7	1358	606	5.4-22
178	Reno	NV	2181	5841	428	1068	1401	2180	365	4059	39.3	1306	752	5.4-22
214	Tonopah	NV	2308	5652	427	1130	1502	2742	611	3777	28.4	1257	660	5.4-22
228	Winnemucca	NV	2774	6471	418	1014	1350	2264	486	6366	41.0	1383	608	5.4-22
233	Yucca Flats	NV	1664	4802	450	1112	1399	3378	1041	11568	35.9	1004	670	5.4-16
New Hampshire														
54	Concord	NH	3742	7425	375	630	824	2254	463	1865	22.6	1533	683	5.4-25
New Jersey														
114	Lakehurst	NJ	2174	5265	407	712	917	3299	915	3019	20.5	1312	645	5.4-20
151	Newark	NJ	2027	4956	406	710	912	3556	1009	2487	17.7	1325	644	5.4-20

C.3

NO	CITY	STATE	HDD50	HDD65	VSN	VSEW	VSS	CDD50	CDD65	CDH80	DR	NO HRS T<55	8AM-4PM 55≤T≤69	ACP TABLE
	New Mexico													
5	Albuquerque	NM	1633	4423	469	1105	1361	3942	1257	5705	25.3	1148	703	5.4-18
49	Clayton	NM	2138	5176	457	1019	1310	3122	685	2093	20.0	1150	770	5.4-22
184	Roswell	NM	1008	3486	490	1081	1280	4536	1539	11135	26.1	825	677	5.4-18
217	Truth or Consequences	NM	1074	3592	488	1113	1326	4457	1500	6882	23.4	889	744	5.4-18
219	Tucumcari	NM	1344	3922	470	1046	1300	4451	1554	8424	26.9	914	710	5.4-18
	New York													
4	Albany	NY	3488	6770	395	719	942	2812	619	1308	19.7	1487	605	5.4-25
27	Binghampton	NY	3885	7397	370	592	733	2373	410	672	18.5	1657	662	5.4-25
34	Buffalo	NY	3213	6721	371	609	746	2476	509	779	19.2	1571	697	5.4-25
131	Massena	NY	4583	8397	380	708	942	2026	365	913	20.9	1674	627	5.4-26
149	New York (Central Pk)	NY	1986	5022	392	650	817	3273	834	911	12.5	1335	790	5.4-20
150	New York (LAG)	NY	1986	5022	392	650	817	3273	834	911	12.5	1335	790	5.4-20
182	Rochester	NY	3482	6995	374	622	771	2557	595	1642	20.1	1612	608	5.4-25
210	Syracuse	NY	3448	6856	371	611	764	2579	513	926	20.2	1521	730	5.4-25
	North Carolina													
13	Asheville	NC	1407	4203	449	782	946	3442	763	1298	21.1	1083	915	5.4-15
37	Cape Hatteras	NC	635	2745	460	819	972	4978	1613	2039	10.0	765	820	5.4- 7
43	Charlotte	NC	1086	3412	456	809	968	4698	1549	4299	19.6	892	777	5.4-17
45	Cherry Point	NC	569	2556	461	826	996	5277	1788	3614	15.2	690	757	5.4- 7
90	Greensboro	NC	1261	3760	449	810	994	4274	1298	3642	17.4	1018	718	5.4-17
174	Raleigh	NC	1131	3509	445	774	935	4485	1389	3697	16.5	918	740	5.4-17
	North Dakota													
29	Bismarck	ND	5196	8992	371	766	1114	2175	496	2067	27.8	1724	556	5.4-29
77	Fargo	ND	5582	9242	371	751	1077	2388	573	2288	22.2	1730	546	5.4-29
141	Minot	ND	5336	9178	358	724	1059	2064	431	1570	24.5	1800	581	5.4-29
	Ohio													
3	Akron	OH	2881	6172	396	664	812	2845	661	1100	17.3	1460	680	5.4-21
53	Columbus	OH	2424	5493	401	671	819	3195	789	2268	22.6	1375	708	5.4-20
59	Dayton	OH	2573	5549	408	696	855	3367	868	1346	17.1	1388	611	5.4-20
213	Toledo	OH	3132	6514	393	676	853	2791	698	1794	17.8	1500	652	5.4-21
232	Youngstown	OH	3129	6557	383	624	760	2593	546	1128	21.4	1523	679	5.4-21
	Oklahoma													
157	Oklahoma City	OK	1417	3825	465	875	1053	4901	1834	8878	20.8	980	733	5.4-18
220	Tulsa	OK	1429	3732	453	820	991	5244	2072	10065	19.7	983	591	5.4-19
	Oregon													
14	Astoria	OR	1080	5226	350	588	782	1357	29	145	12.3	1571	1236	5.4-14
133	Medford	OR	1531	4893	405	814	1005	2681	568	4081	32.9	1442	749	5.4-15
154	North Bend	OR	629	4678	392	740	977	1429	2	0	11.8	1351	1553	5.4- 4
170	Portland	OR	1151	4577	364	647	841	2321	272	1086	22.8	1421	1060	5.4-14
177	Redmond	OR	2535	6665	395	835	1127	1573	228	2390	34.4	1631	695	5.4-20
187	Salem	OR	1128	4926	373	680	874	1849	172	1224	29.3	1499	916	5.4-14
	Pennsylvania													
6	Allentown	PA	2692	5760	401	682	864	3105	698	1146	17.0	1335	710	5.4-21
18	Avoca	PA	2931	6236	389	646	811	2823	652	1547	19.7	1505	705	5.4-21
74	Erie	PA	3006	6426	384	646	792	2527	472	378	14.8	1532	716	5.4-21
94	Harrisburg	PA	2302	5251	404	687	864	3518	992	2860	20.1	1342	648	5.4-20
162	Philadelphia	PA	2044	4923	408	701	889	3661	1065	3172	17.1	1286	646	5.4-20
165	Pittsburgh	PA	2773	5907	392	642	780	2989	648	1040	19.0	1426	700	5.4-21
	Rhode Island													
172	Providence	RI	2610	6022	393	677	874	2756	693	1284	16.8	1429	684	5.4-21
	South Carolina													
41	Charleston	SC	435	2194	467	796	925	5722	2005	5249	16.4	570	767	5.4- 9
52	Columbia	SC	694	2666	467	816	953	5613	2110	8541	19.5	741	705	5.4- 9
91	Greenville	SC	907	3220	459	814	971	4563	1400	3494	17.7	866	851	5.4- 7

C.4

NO CITY	STATE	HDD50	HDD65	VSN	VSEW	VSS	CDD50	CDD65	CDH80	DR	NO HRS 8AM-4PM T<55	55≤T≤69	ACP TABLE
South Dakota													
100 Huron	SD	4820	8351	390	769	1044	2718	774	3739	24.5	1630	545	5.4-26
164 Pierre	SD	4028	7358	392	822	1147	3079	934	5262	24.2	1564	557	5.4-26
175 Rapid City	SD	3672	7229	394	819	1142	2581	663	3477	28.2	1530	572	5.4-25
203 Sioux Falls	SD	4240	7683	394	778	1078	2811	779	3029	20.2	1553	599	5.4-26
Tennessee													
44 Chattanooga	TN	1232	3595	444	738	869	4652	1541	5079	17.6	1050	684	5.4-17
108 Knoxville	TN	1283	3818	446	762	898	4455	1514	3840	17.8	1076	703	5.4-17
134 Memphis	TN	1034	3259	460	806	935	5319	2069	7807	19.2	865	851	5.4-19
147 Nashville	TN	1165	3609	443	749	863	4583	1552	5078	18.2	897	749	5.4-17
Texas													
1 Abilene	TX	792	2714	494	924	1066	5968	2416	13206	21.5	760	648	5.4-10
8 Amarillo	TX	1592	4331	471	1013	1253	4113	1377	6763	23.9	1109	680	5.4-18
17 Austin	TX	271	1735	503	877	972	6873	2862	14093	19.3	564	664	5.4-10
32 Brownsville	TX	35	642	547	908	908	8531	3664	12218	14.8	191	422	5.4-12
55 Corpus Christi	TX	106	889	529	906	946	8200	3508	13109	17.2	249	543	5.4-12
61 Del Rio	TX	186	1397	511	903	1008	7376	3112	14870	19.8	474	732	5.4-10
70 El Paso	TX	522	2605	503	1133	1306	5617	2225	13224	21.3	660	735	5.4-10
81 Fort Worth	TX	605	2354	485	875	994	6174	2448	13682	20.5	673	772	5.4-10
99 Houston	TX	195	1346	490	805	883	7215	2891	10569	18.2	352	703	5.4- 9
107 Kingsville	TX	49	874	527	881	922	8302	3652	15512	19.2	260	523	5.4-12
115 Laredo	TX	65	842	532	900	936	8827	4130	25225	21.4	286	598	5.4-13
126 Lubbock	TX	1173	3643	488	1070	1267	4754	1749	9827	25.1	917	743	5.4-18
127 Lufkin	TX	370	1846	492	848	942	6667	2668	11737	21.5	478	681	5.4-10
137 Midland	TX	634	2573	504	1079	1247	5695	2159	11177	25.9	698	729	5.4-10
168 Port Arthur	TX	167	1416	497	824	900	6888	2662	8837	17.4	384	697	5.4- 9
189 San Angelo	TX	538	2110	503	944	1076	6522	2619	14621	20.6	641	619	5.4-10
190 San Antonio	TX	261	1579	510	878	955	7170	3013	13841	20.1	462	690	5.4-10
200 Sherman	TX	699	2708	476	862	996	5844	2378	12065	20.2	785	721	5.4-10
221 Waco	TX	488	2166	495	874	972	6676	2879	15658	21.1	651	622	5.4-10
226 Wichita Falls	TX	984	3049	480	911	1077	5708	2299	14487	18.8	802	723	5.4-10
Utah													
33 Bryce Canyon	UT	4709	9288	445	1063	1386	899	4	69	30.0	1660	841	5.4-28
40 Cedar City	UT	2592	5888	447	1054	1342	2802	624	3119	27.1	1392	629	5.4-22
188 Salt Lake City	UT	2570	5975	422	975	1266	3011	941	7030	29.1	1426	586	5.4-22
Vermont													
36 Burlington	VT	4211	7932	382	698	925	2118	365	490	18.3	1697	637	5.4-26
Virginia													
153 Norfolk	VA	1185	3609	443	792	964	4636	1586	4554	15.0	1014	685	5.4-17
179 Richmond	VA	1322	3895	430	745	923	4225	1323	4021	17.6	996	716	5.4-17
180 Roanoke	VA	1520	4192	433	763	946	3986	1183	3306	19.0	1148	713	5.4-17
Washington													
158 Olympia	WA	1546	5550	351	619	819	1550	79	466	26.4	1577	985	5.4-14
198 Seattle/Tacoma	WA	1382	5281	350	621	828	1683	106	256	16.5	1700	982	5.4-14
205 Spokane	WA	2983	6727	363	758	1064	2094	363	1595	25.3	1669	640	5.4-21
225 Whidbey Island	WA	1179	5274	344	630	878	1403	22	7	14.8	1671	1169	5.4-14
230 Yakima	WA	2323	5877	373	790	1091	2370	449	3285	31.2	1413	703	5.4-20
West Virginia													
42 Charleston	WV	1816	4587	409	667	798	3712	1008	3054	20.8	1215	704	5.4-20
Wisconsin													
69 Eau Claire	WI	4751	8285	376	683	923	2545	603	1898	18.2	1565	661	5.4-26
89 Greenbay	WI	4310	8039	380	696	947	2172	426	957	22.1	1604	651	5.4-26
112 La Crosse	WI	3838	7243	386	701	937	2786	716	2121	18.9	1568	644	5.4-25
129 Madison	WI	4009	7466	391	717	955	2559	542	1329	19.1	1511	658	5.4-26
139 Milwaukee	WI	3586	7121	396	724	941	2427	487	1013	17.1	1587	618	5.4-25

C.5

NO	CITY	STATE	HDD50	HDD65	VSN	VSEW	VSS	CDD50	CDD65	CDH80	DR	NO HRS T<55	8AM-4PM 55≤T≤69	ACP TABLE
Wyoming														
39	Casper	WY	3824	7617	403	961	1343	2177	495	2699	29.8	1670	535	5.4-27
46	Cheyenne	WY	3435	7218	416	906	1267	1963	271	1040	26.4	1618	608	5.4-27
183	Rock Springs	WY	4407	8391	411	1012	1395	1698	207	702	29.1	1828	552	5.4-28
199	Sheridan	WY	3605	7366	387	806	1133	2074	360	2105	30.8	1650	574	5.4-25
Other Locations Outside U.S.A.														
92	Guantanamo Bay	CU	0	0	612	1045	1018	11071	5596	18452	15.5	0	17	5.4- 3
110	Koror Island	PN	0	0	662	890	827	11435	5960	14548	9.5	0	0	5.4- 3
111	Kwajalein Island	PN	0	0	678	961	888	11635	6160	16217	8.2	0	0	5.4- 3
193	San Juan	PR	0	0	608	963	931	10648	5173	11563	12.7	0	14	5.4- 3
222	Wake Island	PN	0	0	609	1002	977	10869	5394	10167	9.7	0	0	5.4- 3

C.6

ATTACHMENT 5B TO SECTION 435.105
EQUATIONS TO DETERMINE EXTERNAL WALL HEATING AND COOLING CRITERIA
AND
TO DETERMINE COMPLIANCE WITH THE CRITERIA

5B.1 Equations and Coefficients

This attachment contains the external wall equations for use in determining external wall heating and cooling criteria (WC_h and WC_c) and for determining compliance (H_i and C_i) with the criteria for north, east, south and west orientations. For NE, NW, SW and SE orientations, WC_h, WC_c, H_i and C_i shall be determined by treating half of each wall area as though it faces each of the adjacent cardinal directions, e.g., treat NE as half north and half east.

Equations 5.5-2 and 5.5-6 are statistical regression equations that correlate envelope cooling and heating loads, respectively, from thermal transmission and solar gains, as modified by internal gain and mass, to the physical components of the envelope. Seven individual terms are identified for both cooling and heating that correlate variables with physical meaning such as U-values, internal gains, and weather related variables. They are as follows:

1. CLU, CLUO, CLXUO: Terms that correlate cumulative annual cooling loads with thermal transmittance of the wall.

2. CLM: Term that correlates cumulative annual cooling loads with heat capacity of the wall.

3. CLG: Term that correlates cumulative annual cooling loads with internal gains from occupant light and equipment.

4. CLS: Term that correlates cumulative annual cooling loads with incident solar gains.

5. CLC: Term that correlates cumulative annual cooling loads with climate variables for a specific location.

6. HLU, HLUO, HLXUO: Terms that correlate cumulative annual heating loads with thermal transmittance of the wall.

7. HLM: Term that correlates cumulative annual heating loads with heat capacity of the wall.

8. HLG: Term that correlates cumulative annual heating loads with internal gains from occupants, lights, and equipment.

9. HLS: Term that correlates cumulative annual heating loads with incident solar gains.

10. HLC: Term that correlates cumulative annual heating loads with climate variables for a specific location.

The cooling and heating equations with their coefficients follow.

Cooling Equation

$$WC_c \text{ or } C_1 = CLU_i + CLUO_i + CLXUO_i + CLM_i + CLG_i + CLS_i + CLC_i$$

Equation 5.5-2

Where:

i = for each orientation

j = for each wall mass construction type for the orientation

$$CLU = FO \times U_{OW} \times [\, CU1 \times CDH80 + CU2 \times CDH80^2 + CU3 \times (VS \times CDH80)^2 + CU4 \times DR \,]$$

$$CLUO = FC \times UOC \times [\, CUO1 \times EA \times VS \times CDD50 + CUO2 \times G + CUO3 \times G^2 \times EA^2 \times VS \times CDD50 + CUO4 \times G^2 \times EA^2 \times VS \times CDD65 \,]$$

$$CLXUO = FC \times 1/UOC \times [\, CXUO1 \times EA \times VS \times CDD50 + CXUO2 \times EA \times (VS \times CDD50)^2 + CXUO3 \times G \times CDD50 + CXUO4 \times G^2 \times EA^2 \times VS \times CDD50 + CXUO5 \times G^2 \times CDD65 \,]$$

$$CLM = FO_j \times CMC_i \times [\, CM1 + CM2 \times EA \times VS \times CDD50 + CM3 \times EA \times VS \times CDD65 + CM4 \times EA^2 \times VS \times CDD50 + CM5 \times G^2 \times CDD65 + CM6 \times G \times CDD50 + CM7 \times G \times CDD65 + CM8 \times G \times EA \times VS \times CDD50 \,]$$

$$CLG = FC \times \{\, G \times [\, CG1 + CG2 \times CDD50 + CG3 \times EA \times (VS \times CDD50)^2 + CG4 \times EA^2 \times VS \times CDD50 + CG5 \times CDD65 + CG6 \times CDD50^3 + CG7 \times CDD65^3 \,] + G^2 \times [\, CG8 \times EA \times VS \times CDD50 + CG9 \times EA^2 \times VS \times CDD50 \,] \,\}$$

$$CLS = FC \times (EA \times [CS1 + CS2 \times VS \times CDD50 + CS3 \times (VS \times CDD50)^2 + CS4 \times VS \times CDD65 + CS5 \times (VS \times CDD65)^2] + EA^2 \times [CS6 + CS7 \times (VS \times CDD65)^2])$$

$$CLC = FC \times [CC1 \times CDD50 + CC2 \times CDD50^2 + CC3 \times CDH80 + CC4 \times CDH80^2 + CC5 \times CDD65 + CC6 \times (VS \times CDD65)^2 + CC7 \times VS \times CDD50 + CC8 \times (VS \times CDD50)^2 + CC9 \times (VS \times CDH80)^2 + CC10 \times VS + CC11 \times DR + CC12 \times DR^2 + CC13]$$

NOTE: The coefficients for various orientations in the equations listed above are found in Table 5B-2. If WC_c or C_1 is less than 0.0, WC_c or C_1 is set equal to 0.0.

Where:

Climate Data

CDD50 = Cooling degree-days base 50 °F

CDD65 = Cooling degree-days base 65 °F

CDH80 = Cooling degree-hours base 80 °F

DR = Average daily temperature range for warmest month.

VS = Annual average daily incident solar energy on facade under consideration, $Btu/ft^2/day$.

Building Data

FC = Wall area (opaque and glazed) of zone under consideration divided by total wall area (opaque and glazed) of all zones.

FO = Opaque wall area of zone under consideration divided by total wall area (opaque and glazed) of all zones. If multiple mass constructions are present, the FO_j is calculated for each construction j and used to form the area weighted mass correction.

U_{OW} = Area average U-value of opaque walls (including those of mass construction) in zone under consideration.

UOC = Area average U-value of wall (opaque and glazed, evaluated under cooling conditions) in zone under consideration. UOC is equal to UOH.

WWR = Window wall ratio for zone under consideration; defined as fenestration area divided by total wall area (opaque and glazed).

EA = Effective aperature fraction for zone under consideration, where:

$$EA = WWR \times SC_x \times S_{ec}$$

Equation 5.5-3

Where:

S_{ec} = The cooling adjustment factor for horizontal external shading projections:

For $0.0 \leq PF \leq 0.5$ from Equation 5.4-1

For the north orientation:

$$S_{ec} = 1 - 0.4 \times PF$$

Equation 5.5-3a

For the east, south and west orientations:

$$S_{ec} = 1.0 - 1.4877 \times PF + 1.0489 \times PF^2$$

Equation 5.5-3b

G = Effective internal gain (W/ft^2) for zone under consideration, where:

$$G = E_p + L_p \times (1 - R_c \times K_d) + O_l$$

Equation 5.5-4

Where:

L_p = Lighting power, from Section 5.5.7.4

E_p = Equipment power, from Section 5.5.7.5

R_c = The ratio of the electric lights in the same space served by the orientation that have automatic controls for daylighting.

O_l = Occupant load adjustment, from Section 5.5.7.6

$$K_d = 5.871 \,(WWR \times VLT \times S_{ec}) - 13.311 \,(WWR \times VLT \times S_{ec})^2$$

Equation 5.5-4a

If $(WWR \times VLT \times S_{ec}) > 0.22$, then $K_d = 0.647$

Where:

WWR = As defined above, but not to exceed a maximum value of 0.65 in Equation 5.5-4a, per Section 5.5.7.3.

VLT = Visible light transmittance of the glazing material, as defined in Section 5.5.2.1, including any shading devices present that modify the visible transmittance of the glazing material.

CMC = Mass correction (Cooling Delta Load Factor) from Equation 5.5-5. If multiple mass constructions are present, each CMC_j is evaluated separately and combined by area weighting. If the U-value of the mass wall is less than 0.05, then $U_{ow} = 0.05$ shall be used to calculate the CMC. If the value of HC is greater than 20, then HC = 20 shall be used to calculate the CMC.

COOLING DELTA LOAD FACTOR EQUATIONS

Equation 5.5-5 is used to predict the Cooling Delta Load Factor values.

CMC = Cooling Delta Load Factor =

$$\left|1 - e^{-CP_1(HC-1)}\right| \left| CP_2 + CP_3U - \frac{CP_4}{1 + (CP_5 + CP_6U)e^{-(CP_7+CP_8U^2)(HC-1)}} \right| \left| \frac{1.0}{0.7} \right|$$

Equation 5.5-5

Where:

HC = Wall Heat Capacity ($Btu/ft^2 \cdot {}^oF$).

U = Wall U-Value ($Btu/h/ft^2 \cdot {}^oF$).

A = (Cooling degree-hours base 80 ^oF)/10000 + 2 ($^oF \cdot h$).

B = (Daily Range)/10 + (^oF).

Where:

$CP_1 = C_5$

$CP_2 = C_{15}/B^3 + C_{16}/(A^2B^2)+C_{17}$

$CP_3 = C_1/A^3 + C_2B^3 + C_2B^3 + C^3/(A^2 \sqrt{B}) + C_4$

$CP_4 = C_{12}/(A^2B^2) + C_{13}/B^3 + C_{14}$

$CP_5 = C_{18}$

$CP_6 = C_6LN(A) \sqrt{B} + C_7$

LN = Natural Logarithm

$CP_7 = C_{19}/(A^2B^2) + C_{20}/(AB) + C_{21}A^2/ \sqrt{B} + C_{22}$

$CP_8 = C_8/(A^2B^2) + C_9/(AB) + C_{10}A^2/ \sqrt{B} + C_{11}$

The coefficients C1 through C22 are taken from the following table, Table 5B-1.

HEATING EQUATION

$$WC_h \text{ or } H_1 = \Sigma (HLU_i + HLUO_i + HLXUO_i + HLM_i + HLG_i + HLS_i + HLC_i)$$

Equation 5.5-6

Where:

i = for each orientation

j = for each wall mass construction type for the orientation

$HLU = FO \times U_{ow} \times [HU1 \times HDD50 + HU2 \times (VS \times HDD65)^2]$

$HLUO = FC \times UOH \times [HUO1 \times HDD50 + HUO2 \times HDD65 + HUO3 \times EA \times VS \times HDD65]$

$HLXUO = FC \times ((1/UOH) \times [HXUO1 \times EA \times (VS \times HDD50)^2 + HXUO2 \times EA \times (VS \times HDD65)^2] + (1/UOH^2) \times [HXUO3 \times EA^2 \times VS \times HDD65])$

$HLM = FO_j \times HMC_j \times [HM1 + HM2 \times G \times UOH \times HDD65 + HM3 \times G^2 \times EA^2 \times VS \times HDD50 + HM4 \times UOH \times EA \times VS \times HDD65 + HM5 \times UOH \times HDD50 + HM6 \times EA \times (VS \times HDD65)^2 + HM7 \times EA^2 \times VS \times HDD65/UOH]$

$$HLG = FC \times (G \times [HG1 \times HDD65 + HG2 \times UOH \times HDD65 + HG3 \times EA \times VS \times HDD65 + HG4 \times EA^2 \times VS \times HDD50] \times G^2 \times [HG5 \times HDD65 + HG6 \times EA^2 \times VS \times HDD65])$$

$$HLS = FC \times (EA \times [HS1 \times VS \times HDD65 + HS2 \times (VS \times HDD50)^2] + EA^2 \times [HS3 \times VS \times HDD50 + HS4 \times VS \times HDD65])$$

$$HLC = FC \times [HC1 + HC2 \times HDD65 + HC3 \times HDD65^2 + HC4 \times VS^2 + HC5 \times VS \times HDD50 + HC6 \times VS \times HDD65 + HC7 \times (VS \times HDD50)^2]$$

NOTE: The coefficients for various orientations in the equations listed above are found in Table 5B-4. If WC_h or H_1 is less than 0.0, WC_h or H_1 is set equal to 0.0.

Where:

Climate Data

HDD50 = Heating degree-days base 50 °F.

HDD65 = Heating degree-days base 65 °F.

VS = Annual average daily incident solar energy on facade under consideration, Btu/ft^2-day.

Building Data

FC = Wall area (opaque and glazed) of zone under consideration divided by total wall area (opaque and glazed) of all zones.

FO = Opaque wall area of zone under consideration divided by total wall area (opaque and glazed) of all zones. If multiple mass constructions are present, the FO_i is calculated for each and used to form the area weighted mass correction.

U_{OW} = Area average U-value of opaque walls (including those of mass construction) in zone under consideration.

UOH = Area average U-value of wall (opaque and glazed, evaluated under heating conditions) in zone under consideration. UOH is equal to UOC.

WWR = Window wall ratio for zone under consideration; defined as fenestration area divided by total wall area (opaque and glazed).

EA = Effective aperature fraction for zone under consideration.

$$EA = WWR \times SC_x \times S_{eh}$$

Equation 5.5-7

Where:

For $0.0 \leq PF \leq 0.5$, from Equation 5.4-1:

For the north orientation:

$$S_{eh} = 1 - 0.3 \times PF$$

Equation 5.5-7a

For the east, south and west orientation:

$$S_{eh} = 1 - 0.986 \times PF + 0.4513 \times PF^2$$

Equation 5.5-8

G = Effective internal gain (W/ft^2) for zone under consideration.

$$G = E_p + L_p \times (1 - R_c \times K_d) + O_l$$

Equation 5.5-8

Where:

L_p = Lighting power, from Section 5.5.7.4.

E_p = Equipment power, from Section 5.5.7.5.

O_l = Occupant load adjustment, from Section 5.5.7.6

R_c = The ratio of the electric lights in the space served by the orientation that have automatic controls for daylighting.

$$K_d = 5.871\ (WWR \times VLT \times S_{eh}) - 13.311\ (WWR \times VLT \times S_{eh})^2$$

Equation 5.5-8a

If WWR x VLT x S_{eh} > 0.22, then K_d = 0.647

Where:

WWR = As defined above, but not to exceed a maximum value of 0.65 in Equation 5.5-8a per Section 5.5.7.3.

VLT = Visible light transmittance of the glazing material, as defined in Section 5.5.2.1 including any shading devices present that modify the visible transmittance of the glazing material.

HMC = Mass correction from Equation 5.5-9. If multiple mass constructions are present, each HMC_j is evaluated separately and combined by area weighting. If the U-value of the mass wall is greater than 0.40, then U_{ow} = 0.4 shall be used to calculate the HMC. If the U-value of the mass wall is less than 0.05, then U_{ow} = 0.05 shall be used to calculate the HMC. If the value of HC is greater than 20, then HC = 20 shall be used to calculate the HMC.

HEATING DELTA LOAD FACTOR EQUATIONS

Equation 5.5-9 is used to predict the heating Delta Load Factor values.

HMC = Heating Delta Load Factor =

$$\left|1 - e^{-HP_1(HC-1)}\right| \left| HP_2 + HP_3 U - \frac{HP_4}{1 + (HP_5 + HP_6 U)e^{-(HP_7 + HP_8 U^2)(HC-1)}}\right| \frac{1.0}{0.7}$$

Equation 5.5-9

Where:

HC = Wall Heat Capacity ($Btu/ft^2 \cdot {}^oF$)

U = Wall U-Value ($Btu/h \cdot ft^2 - {}^oF$)

A = (Heating degree-days base 65 ^oF/100 + 2 ($^oF \cdot$days)

Where:

$HP_1 = H_6$

$HP_2 = H_{14}LN(A)+H_{15}$

LN = Natural Logarithm

$HP_3 = H_1A^3+H_2A^2+H_3/\sqrt{A} + H_4\sqrt{A} + H_5$

$HP4 = H_{11}A^2+H_{12}/A^2+H_{13}$

$HP_5 = H_{16}$

$HP_6 = H_7A+H_8$

$HP_7 = H_{17}/A^3+H_{18}$

$HP_8 = H_9/A^3+H_{10}$

The coefficients H1 through H18 are taken from the following table, Table 5B-3.

5B.2 Determining Heating and Cooling Criteria Using Equations in Section 5B.1

To determine the wall thermal criteria for a building design, the following inputs to the equations in Section 5B.1 shall be used.

(1) **Aspect Ratio.** An aspect ratio of 2:1 with longer dimensions facing east and west.

(2) **Shading.** No use of external shading projections or screens.

(3) **Daylight Controls.** No use of automatic daylight controls for the lighting system.

(4) **Internal Gain (G).** The sum of the lighting power density (L_p), the equipment power density (E_p) and the occupant load adjustment (O_l), or 3.0 W/ft^2, whichever is smaller, shall be used. In determining L_p, the value of R_c and VLT shall be set equal to 0.0 in Equations 5.5-4 and 5.5-8.

(5) **Wall Area Factor, Opaque and Glazed (FC).** The combined opaque and glazed area for the orientation for the building design, divided by the total wall area (opaque and glazed) of all orientations, shall be used. Note that if one changes the wall area or floor area in a zone, this changes the geometry of the building. The criteria and compliance values will change for all zones because both values for each zone are weighted by the relative size of that zone.

(6) **Window Wall Ratio (WWR).** The smaller of the values of WWR_c and WWR_h determined from (a) and (b) below shall be used.

(a) Using the value for internal gain (G) determined in (4) above, the WWR_c for cooling by interpolation of the results of (a) and (b) below, shall be determined using Equation 5.5-10:

Where: WWR_{g0} is the window to wall ratio at 0.0 W/ft^2 internal load (G = 0.0 W/ft^2).

WWR_{g30} is the window to wall ratio at 3.0 W/ft^2 internal load (G = 3.0 W/ft^2).

$$WWR_c = WWR_{g0} - (G / 3.0) \times (WWR_{g0} - WWR_{g30})$$

Equation 5.5-10

For G = 0.0:

If CDD50 x VSEW < 8,000,000, then Equation 5.5-11 shall be used.

$$WWR_{g0} = 0.48 - (CDD50 \times VSEW \times 1.625 \times 10^{-8})$$

Equation 5.5-11

If CDD50 x VSEW ≥ 8,000,000, then Equation 5.5-12 be used:

$$WWR_{g0} = 0.34$$

Equation 5.5-12

For G = 3.0:

If CDD50 x VSEW < 8,000,000, then Equation 5.5-13 shall be used:

$$WWR_{g30} = 0.28 - (CDD50 \times VSEW \times 5.0 \times 10^{-9})$$

Equation 5.5-13

If CDD50 x VSEW $\geq$ 8,000,000, then Equation 5.5-14 shall be used:

$$WWR_{g30} = 0.24$$

Equation 5.5-14

(b) The WWR_h for heating shall be determined using Equation 5.5-15 or Equation 5.5-16.

If HDD65 < 4000, then Equation 5.5-15 shall be used:

$$WRR_h = 0.4 - (HDD65 \times 2.5 \times 10^{-5})$$

Equation 5.5-15

If HDD65 $\geq$ 4000, then Equation 5.5-16 shall be used:

$$WRR_h = 0.3$$

Equation 5.5 16

(7) **Opaque Wall Area Factor (FO).** The value of FO shall be determined from Equation 5.5-17.

$$FO = FC \times (1 - WWR)$$

Equation 5.5-17

(8) **Shading Coefficient (SC_x).** The value of SC_x shall be determined from (a) or (b) below, or as shown in Figure 5B-3.

(a) If the heating degree-days base 65 °F for the building location is $\leq$ to 3000, either Equation 5.5-18 or Equation 5.5-19 shall be used:

If CDD50 x VSEW < 4,000,000, then Equation 5.5-18 shall be used:

$$SC_x = 0.85 - (CDD50 \times VSEW \times 8.75 \times 10^{-8})$$

Equation 5.5-18

If CDD50 x VSEW $\geq$ 4,000,000, then Equation 5.5-19 shall be used:

$$SC_x = 0.5$$

Equation 5.5-19

(b) If the heating degree days base 65 °F for the building location is > 3000, either Equation 5.5-20 or Equation 5.5-21 shall be used:

If CDD50 x VSEW < 4,000,000, then Equation 5.5-20 shall be used:

$$SC_x = 0.85 - (CDD50 \times VSEW \times 1.25 \times 10^{-7})$$

Equation 5.5-20

If CDD50 x VSEW $\geq$ 4,000,000, then Equation 5.5-21 shall be used:

$$SC_x = 0.35$$

Equation 5.5-21

(9) **External Shading Projection (S_{eh}).** The value of S_{eh} shall be set equal to 0.0.

(10) **Opaque Wall U-Value (U_{ow}).** The value of U_{ow} shall be determined from either Equation 5.5-22 or Equation 5.5-23, as shown in Figure 5B-4.

If HDD65 < 196, then Equation 5.5-22 shall be used:

$$U_{ow} = 1.0$$

Equation 5.5-22

If HDD65 ≥ 196, then Equation 5.5-23 shall be used:

$$U_{ow} = 42.787 \times HDD65^{(-0.712)}$$

Equation 5.5-23

(11) **Heat Capacity of Opaque Wall (HC).** The value of HC shall be set equal to 1.0.

(12) **Fenestration Assembly U-Value (U_{of}).** The value of U_{of} shall be determined from either Equation 5.5-24, 5.5-25, or 5.5-26; or as shown in Figure 5B-5.

If HDD65 < 3000, then Equation 5.5-24 shall be used:

$$U_{of} = 1.15$$

Equation 5.5-24

If HDD ≥ 3000 and HDD65 < 7500, then Equation 5.5-25 shall be used:

$$U_{of} = 0.81 - [(HDD65 - 3000) \times 8.0 \times 10^{-5}]$$

If HDD ≥ 7500, then Equation 5.5-26 shall be used:

$$U_{of} = 0.45$$

Equation 5.5-26

(13) For all other inputs to the equations in Section 5B.1, the values for the building envelope design under consideration shall be used.

Table 5B-1
COOLING DELTA LOAD COEFFICIENTS

COEFFICIENT LABEL	INSULATION POSITION		
	EXTERIOR	INTEGRAL	INTERIOR
C1	220.724503	139.105667	181.616776
C2	-.056589	-.033991	-.055196
C3	-118.835388	-10.326704	-34.158966
C4	-13.674420	-20.867386	-25.591934
C5	.236381	.283882	.081029
C6	.959588	.305851	1.418998
C7	-.255004	.022622	.432421
C8	-905.677979	-307.943848	-1882.926758
C9	425.191895	80.209610	443.195801
C10	-2.510600	.049955	.430200
C11	-43.387955	-5.989545	-28.285065
C12	-259.723389	-11.396114	-63.562256
C13	-33.975525	.366851	20.844650
C14	20.488235	30.253494	9.817521
C15	-26.209152	8.833706	24.459824
C16	-241.173386	-22.254623	-70.337494
C17	18.897781	29.329697	9.884280
C18	-.353790	-.023878	-.114646
C19	156.305634	63.322754	326.344727
C20	-74.098999	-16.334656	-77.635498
C21	.445363	-.011114	-.074788
C22	7.496696	1.295576	5.204088

TABLE 5B-2

COOLING COEFFICIENTS

	NORTH	EAST	SOUTH	WEST
CU1	0.001539	0.003315	0.003153	0.00321
CU2	-0.308548E-07	-0.896618E-07	-0.712993E-07	-0.810530E-07
CU3	0.799493E-13	0.379280E-13	0.183083E-13	0.339810E-13
CU4	-0.079647	0.163114	0.286458	0.11178
CM1	0.32314	0.515262	0.71477	0.752643
CM2	0.153060E-05	0.138197E-05	0.161630E-05	0.142228E-05
CM3	-0.204322E-05	-0.160240E-05	-0.211063E-05	-0.197938E-05
CM4	-0.753665E-06	-0.767849E-06	-0.664430E-06	-0.740067E-06
CM5	-0.100472E-05	0	0.801057E-05	0.315193E-05
CM6	0.366708E-04	0.356503E-04	0.448106E-04	0.296012E-04
CM7	-0.673045E-04	-0.640938E-04	-0.000119	-0.766719E-04
CM8	-0.238335E-07	-0.472534E-07	-0.497469E-07	0
CUO1	-0.651094E-05	-0.838669E-05	-0.888996E-05	-0.756465E-05
CUO2	-1.040207	-1.507235	-1.512625	-1.238545
CUO3	-0.438254E-05	-0.278828E-05	-0.231352E-05	-0.412567E-05
CUO4	0.126580E-04	0.809874E-05	0.736219E-05	0.106712E-04
CXUO1	0.103744E-05	0.119338E-05	0.118588E-05	0.123251E-05
CXUO2	-0.132180E-12	-0.134656E-12	-0.116252E-12	-0.130002E-12
CXUO3	0.275554E-04	0.202621E-04	0.202365E-04	0.236964E-04
CXUO4	0.974090E-07	0.117514E-06	0.939207E-07	0.136276E-06
CXUO5	-0.118247E-04	-0.909694E-05	-0.909192E-05	-0.111077E-04
CG1	0.891286	0.583388	0.393756	0.948654
CG2	0.001479	0.001931	0.002081	0.001662
CG3	-0.552042E-12	-0.282139E-12	-0.284766E-12	-0.455720E-12
CG4	0.252311E-05	0.370821E-05	0.430536E-05	0.591511E-05
CG5	-0.001151	-0.001745	-0.001864	-0.00153
CG6	0.195243E-11	0	-0.296055E-11	0.316358E-11
CG7	-0.835805E-11	0.101089E-10	0.330027E-10	0
CG8	0.141022E-05	0.753875E-06	0.713300E-06	0.970752E-06
CG9	-0.238887E-05	-0.164961E-05	-0.163927E-05	-0.197363E-05
CS1	46.9871	33.9683	18.32016	29.3089
CS2	0.348091E-04	0.374118E-04	0.340490E-04	0.502498E-04
CS3	0	0	0.271313E-11	0
CS4	-0.166409E-04	0.694779E-05	-0.282181E-04	-0.277158E-04
CS5	0.842765E-11	0	-0.304677E-11	0.291137E-11
CS6	-56.5446	0	26.9954	14.9771
CS7	-0.134764E-10	-0.588097E-11	-0.650089E-11	-0.789218E-11

TABLE 5B-2 (Continued)
COOLING COEFFICIENTS

	NORTH	EAST	SOUTH	WEST
CC1	0.002747	0	0.010349	0.001865
CC2	0	0.318928E-06	-0.304413E-06	0
CC3	-0.000348	0.000319	0.00024	0.000565
CC4	0.122123E-07	-0.775318E-07	-0.271443E-07	-0.544380E-07
CC5	0.012112	0.011894	0.013248	0.009236
CC6	0.104027E-11	-0.622661E-12	-0.205178E-11	0
CC7	-0.124013E-04	-0.706280E-05	-0.165377E-04	-0.602685E-05
CC8	0	0	0.820869E-12	0
CC9	-0.375797E-13	0.606235E-13	0.197598E-13	0.389425E-13
CC10	0.030056	0.023121	0.0265	0.01704
CC11	0	0	-0.271026	-0.244274
CC12	0.002138	0.001103	0.006368	0.007323
CC13	-12.8674	-13.16522	-18.271	-10.1285

Table 5B-3
HEATING DELTA LOAD COEFFICIENTS

COEFFICIENT LABEL	INSULATION POSITION		
	EXTERIOR	INTEGRAL	INTERIOR
H1	.000006	.000007	.000006
H2	-.001537	-.001799	-.001492
H3	13.388575	15.116148	19.831360
H4	1.933217	2.105596	1.457923
H5	-11.896660	-13.305299	-15.562034
H6	.464317	.183966	.071887
H7	.009447	.025504	.026392
H8	-.099954	.045871	.775432
H9	-1223.396240	-622.080078	.200792
H10	-.945353	-.519158	-.637875
H11	-.000067	-.000069	-.000007
H12	3.858493	4.137914	2.424339
H13	7.582887	6.238024	7.980392
H14	-.777369	-.771123	-.169907
H15	9.014718	7.722863	8.585447
H16	.200680	.208271	-.038589
H17	206.638214	105.984894	3.139744
H18	.257293	.198297	.186262

Table 5B-4
HEATING COEFFICIENTS

	NORTH	EAST	SOUTH	WEST
HU1	0.006203	0.007691	0.006044	0.006672
HU2	-0.135868E-11	-0.571616E-12	-0.268998E-12	-0.435663E-12
HM1	0.531005	0.545732	0.837901	0.616936
HM2	0.000152	0.000107	0.000208	0.00015
HM3	-0.531826E-06	-0.106191E-06	-0.682531E-06	-0.264566E-06
HM4	-0.773813E-06	-0.147870E-05	0.211938E-05	-0.457827E-06
HM5	-0.000712	-0.000484	-0.001042	-0.000625
HM6	0.334859E-12	0.495762E-13	0.770190E-13	0.737105E-13
HM7	0.239071E-06	0.275045E-06	-0.389887E-06	0
HUO1	0.004943	0.008683	0.009028	0.008566
HUO2	0.013686	0.011055	0.010156	0.01146
HUO3	-0.110178E-04	-0.868956E-05	-0.732317E-05	-0.898665E-05
HXUO1	0.126940E-11	0.785644E-13	-0.282023E-12	0.304904E-13
HXUO2	-0.730582E-12	-0.810900E-13	0.745599E-13	-0.747184E-13
HXUO3	0.197090E-06	0.194026E-06	0.987587E-07	0.195776E-06
HG1	-0.001051	-0.000983	-0.000981	-0.000948
HG2	-0.001063	-0.00093	-0.000815	-0.000975
HG3	0.299013E-05	0.262269E-05	0.241880E-05	0.249976E-05
HG4	0.749049E-06	-0.111056E-05	-0.216687E-05	-0.856049E-06
HG5	0.000109	0.934310E-04	0.975523E-04	0.862389E-04
HG6	-0.555914E-06	-0.315801E-06	-0.260999E-06	-0.291334E-06
HS1	-0.218248E-04	-0.209216E-04	-0.210885E-04	-0.202049E-04
HS2	0.339179E-11	0.190500E-11	0.148388E-11	0.218215E-11
HS3	-0.653253E-05	-0.223413E-04	-0.184726E-04	-0.240488E-04
HS4	0.223087E-04	0.241331E-04	0.245412E-04	0.230538E-04
HC1	-0.106468	-5.19297	-3.66743	-5.29681
HC2	0.00729	0.007684	0.007175	0.007672
HC3	-0.297600E-06	-0.307837E-06	-0.264192E-06	-0.307127E-06
HC4	0.201569E-05	0.630350E-05	0.332112E-05	0.643491E-05
HC5	0.129061E-04	0.477552E-05	0.325089E-05	0.483233E-05
HC6	-0.128594E-04	-0.618539E-05	-0.463086E-05	-0.625101E-05
HC7	0.275861E-11	0.820051E-12	0.438148E-12	0.809106E-12

Figure 5B–1

Maximum Window to Wall Ratio

Cooling

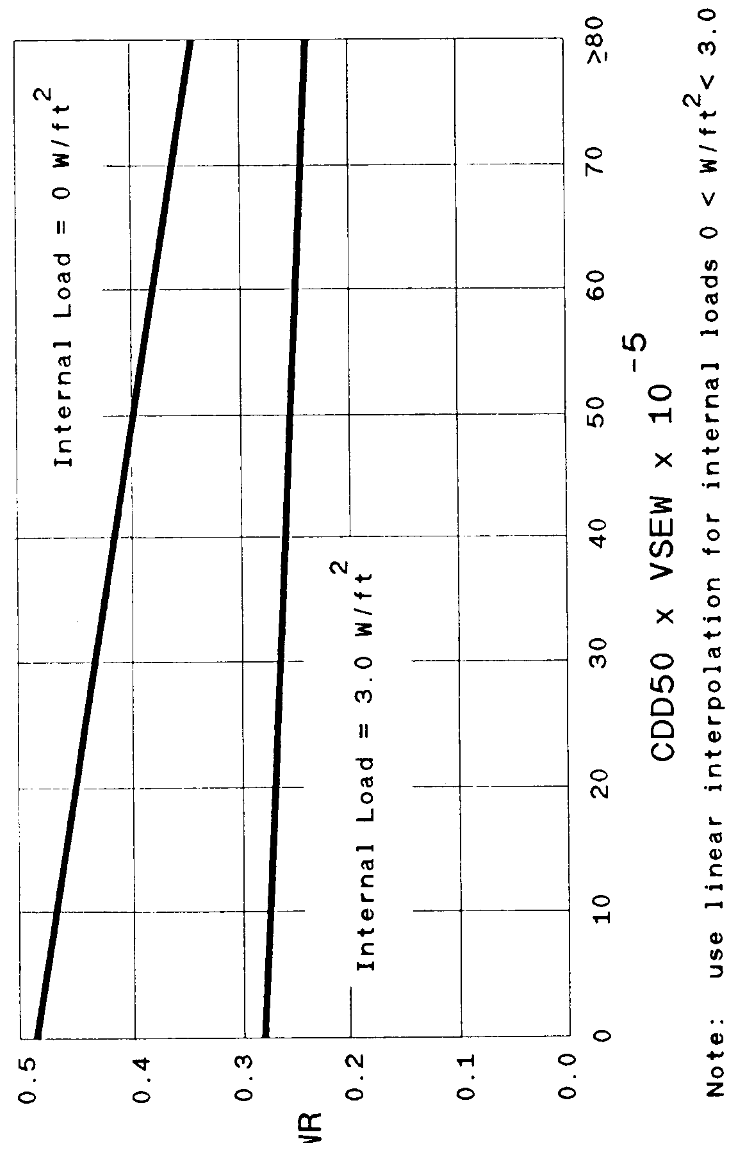


Figure 5B-2

Maximum Window to Wall Ratio

Heating

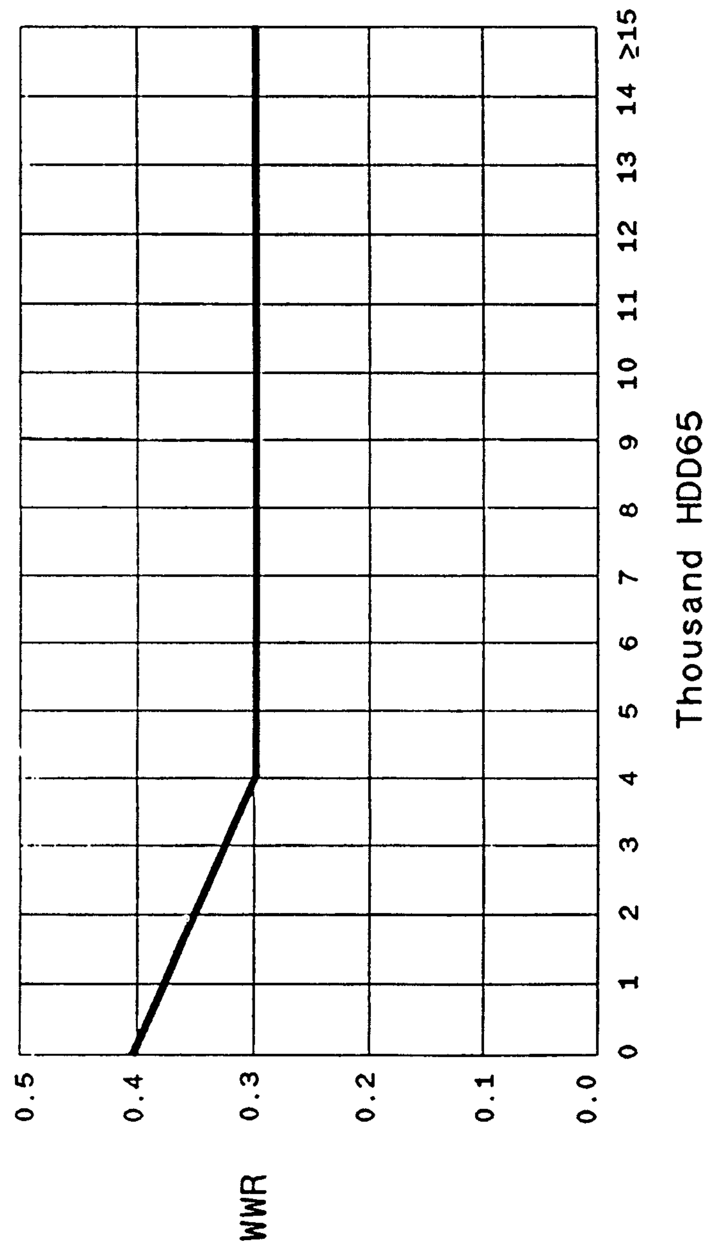


Figure 5B-3

Maximum Shading Coefficient

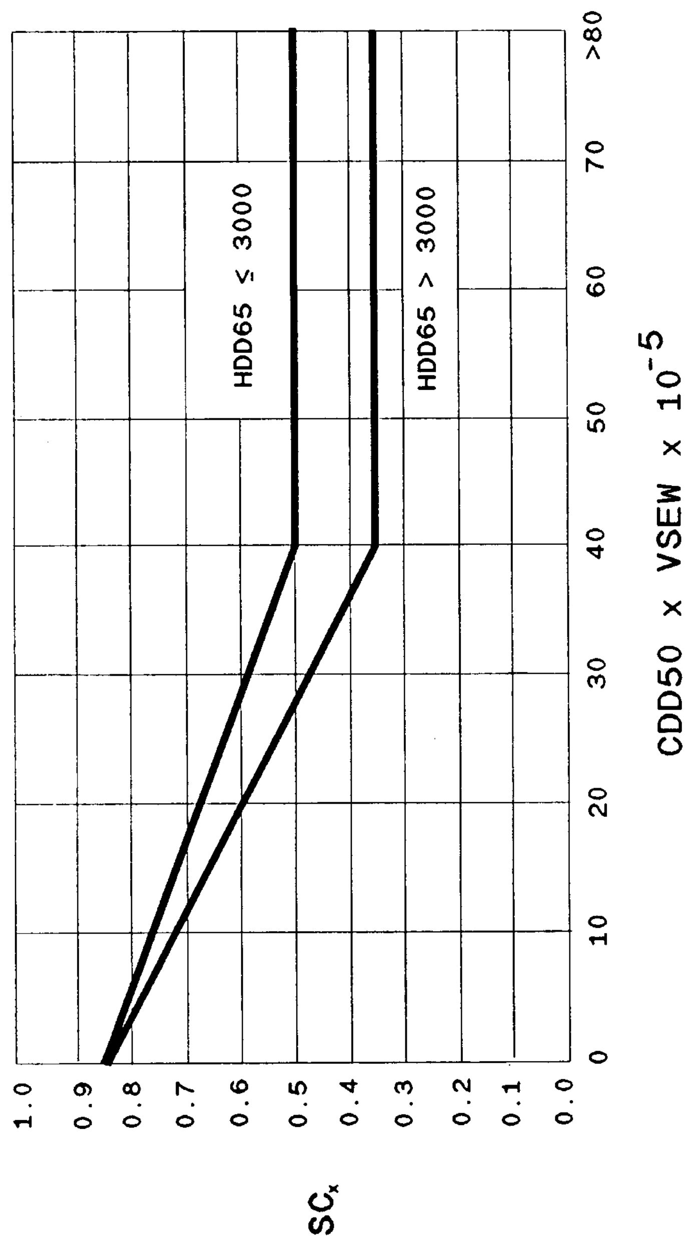
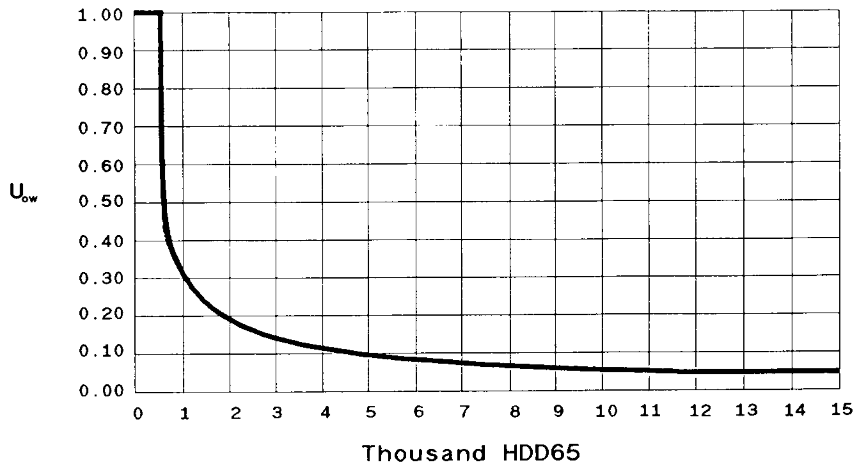


Figure 5B-4

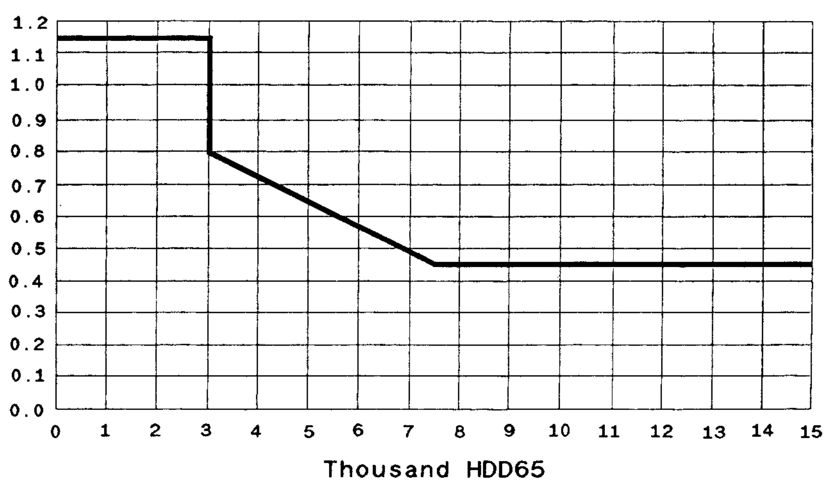
Overall Thermal Transmittance of Opaque Wall Sections



Note: for HDD65 < 196, U_{ow} = 1.0
for 196 ≤ HDD65 ≤ 15000, $U_{ow} = 42.787/\text{HDD65}^{0.712}$

Figure 5B-5

Maximum Overall Thermal Transmittance of Fenestration Assemblies



ATTACHMENT 5C TO 435.105
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Volume 2: Description of the Development Process; Appendix A: Envelope Research Documentation.

Volume 3: Description of the Testing Process; Appendix B: Envelope Compliance Code Documentation.

Volume 4: Documentation of Test Results: (Each in 3 volumes): A: Small Office Building (Branch Bank); B: Medium Office Building; C: Large Office Building; D: Retail Store (Anchor Store); E: Strip Store; F: Apartment House; G: Hotel; H: Warehouse; I: Assembly Building (Church); J: School.

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§ 435.106 Electric power and distribution.

6.1 General

6.1.1 This section contains minimum requirements for all building electrical systems, except required emergency systems.

6.1.2 A building shall be considered in compliance with this section if the minimum requirements of section 6.3 are met.

6.2 Principles of Design

6.2.1 Electric Distribution Systems

6.2.1.1 Transformers and generating units shall be sized as close as possible to the actual anticipated load (i.e., oversizing is to be avoided so that fixed thermal losses are minimized).

6.2.1.2 Distribution of electric power at the highest practical voltage and load selection at the maximum power factor consistent with safety shall be considered. The use of distribution system transformers shall be minimized.

6.2.1.3 Tenant submetering can be one of the most cost-effective energy conservation measures available. A large portion of the energy use in tenant facilities occurs simply because there is no economic incentive to conserve.

6.3 Minimum Requirements

6.3.1 Electrical Distribution System

6.3.1.1 All commercial or multi-family high rise residential buildings, having designed connected electric service over 250 kVA, shall have electrical energy consumption check metered on the basis of usage category or tenant occupancy, depending on conditions defined below. For buildings that are occupied by multiple tenants, the metering shall be per tenant, if the tenant has a connected load of 100 kVA or more. HVAC and service hot water systems, shared among tenants, need not meet this requirement but shall be separately metered.

6.3.1.2 The electrical power feeders for each facility for which check-metering is required shall be by tenant and shall be subdivided in accordance with the following categories:

6.3.1.2.1 Lighting and receptacle outlets;

6.3.1.2.2 HVAC and service water heating systems and equipment; and

6.3.1.2.3 Special occupant equipment or systems of more than 20 kW, such as elevators, computer rooms, kitchens, printing equipment, and baling presses.

6.3.1.2.4 *Exception to Section 6.3.1.2:*

(a) 10% or less of the loads on a feeder may be from another usage category.

6.3.1.3 The power feeders for each category shall contain portable or permanent submetering prior to or within any primary or secondary distribution panels. Such provisions shall include a separate compartment or panel of adequate size and design to house the necessary voltage and current transformers. An accessible means of attaching clamp-on meters or split-core current transformers shall be provided.

6.3.1.4 The locations of these points of measurement may be central or distributed throughout the building, as appropriate to the layout of the building. A minimum arrangement shall provide a safe method for access to the enclosures through which feeder conductors pass, and have sufficient space to attach clamp-on or split-core current transformers. These enclosures may be separate compartments or combined with electrical cabinets serving another function. Enclosures so furnished shall be identified by available measuring function. A preferred arrangement would include kWh meters and demand registers, or a means to transmit such information to a building energy management control system.

6.3.1.5 In multiple-tenant buildings, where designed connected electrical service is over 250 kVA, each tenant space having a total connected load of more than 100 kVA shall have provision made to permit check-metering of the total tenant load. If the building is served by a common HVAC system, the HVAC loads need not be check metered for each tenant.

6.3.2 Transformers

6.3.2.1 All permanently wired transformers, that are part of the building electrical distribution system, except utility-owned transformers, shall be selected to minimize the combination of no-load, part-load, and full-load losses, without compromising the electrical system operating and reliability requirements.

6.3.2.2 If the total capacity of the transformers exceeds 300 kVA, a calculation of total estimated annual operating costs of the transformer losses shall be made. This calculation shall be based on estimated hours of transformer operation at projected part-load and full-load conditions, and the associated transformer core and coil losses. If appropriate data for projecting this calculation is unavailable, use Form 6.3–1 ''Transformer Loss Calculation Estimate'' as a basis for making the estimate. The calculations made in accordance with this section shall be used to compare among types of transformers and configurations available to the designer to balance energy costs with necessary operating flexibility, reliability (redundancy), and safety. The projected annual energy costs for the losses of the selected arrangement shall be retained as part of the electrical design documentation.

FORM 6.3-1
TRANSFORMER LOSS CALCULATION ESTIMATE

Transformer Number ____________
Rated Temperature Rise ____________
Cooling Medium ____________

1. kVA	x	2. 0.	=			3. kW x 8760h	=	4. kWh
(Full-load Rating)	x	(No load Loss)	=			(No load kW) x 8760h	=	(Annual no load Loss)
5. h			x	0.1	x	6. kW	=	7. kWh
(Annual h of operation @ 10% to 50% of load)			x	0.1	x	(Rated Full load coil losses)	=	(Annual part load @ 10% to 50%)
8. h			x	0.5	x	9. kW	=	10. kWh
(Annual h of operation @ 50% to 80% of load)			x	0.5	x	(Rated full load coil losses)	=	(Annual part load @ 50% to 80%)
11. h			x	0.8	x	12. kW	=	13. kWh
(Annual h of operation @ 80% to 100% of load*)			x	8.0	x	(Rated full load coil losses)	=	(Annual part load @ 80% to 100%)
						Total	=	14. kWh
								(Total annual full and part load losses)
15. kWh			x			16 $ /kWh	=	17. $
(Total annual full and part load losses)			x			(Average cost of electricity per kWh)	=	(Total annual cost of transformer losses)

* If transformers are expected to operate regularly (by means of external cooling) at ratings above full-load kVA, a more precise loss calculation procedure is required.

6.3.3 Electric Motors

6.3.3.1 All permanently wired polyphase motors of 1 hp or more serving the building, shall meet the requirements of this section. Motors expected to operate more than 500 hours per year shall have a minimum acceptable nominal full-load motor efficiency no less than that shown in Table 6.3–1.

6.3.3.1.1 Table 6.3–1 applies to motors having nominal 1200, 1800, or 3600 RPM; with open, drip-proof, or TEFC enclosures. Other motor types are exempted from the minimum efficiency requirements of these standards.

6.3.3.1.2 Motor efficiency ratings shall be based on a statistically valid quality control procedure conforming with *ANSI/IEEE 112–1984, Test Method B (Dynamometer)* using *NEMA MG 1–1987* (MG 1–12.54 and MG 1–12.55) for motors below 500 hp. For motors 500 hp and above, *ANSI/IEEE 112–1984, Test Method B or Method F* (Equivalent Circuit Calculation), shall be used.

6.3.3.1.3 Values listed in Table 6.3–1 are nominal efficiencies. Minimum motor efficiencies shall not be less than the corresponding values provided in *NEMA MG 1–12.54*.

TABLE 6.3-1
MINIMUM ACCEPTABLE FULL-LOAD MOTOR EFFICIENCIES FOR SINGLE SPEED POLYPHASE MOTORS[1]

HORSEPOWER	MINIMUM RATES EFFICIENCY PERCENT
1-4	78.5
5-9	84.0
10-19	85.5
20-49	88.5
50-99	90.2
100-124	91.7
125 and above	92.4

1 Motors operating more than 750 hours per year are likely to be cost-effective with efficiencies greater than those listed. The more efficient motors are classified by most manufacturers as "high-efficiency," and are presently available for common applications with typical nominal efficiencies of: 5hp, 89.5%; 10hp, 91.0%; 50hp, 94.1%; 100hp, 95.1%; 200hp, 96.2%. Guidance for evaluating the cost effectiveness of high efficiency motor applications is given in NEMA MG 10-83 (name).

6.3.3.1.4 Motor efficiency shall be tested using a statistically valid quality control procedure conforming with the *IEEE 112A, Test Method B (1978)* (Dynmometer) fan motors E below 500 hp, or *Test Method F (1978)* (Equivalent Circuit Calculation) based on no-load measurements for motors 500 hp and larger.

6.3.3.2 Motor nameplates shall list the minimum and the nominal full-load motor efficiencies and the full-load power factor.

6.3.3.3 Full-load motor power factor for three-phase motors can be calculated from nameplate data by Equation 6.3–1:

% Power Factor=(hp $\times$ 745 $\times$ 100)/(nominal efficiency $\times$ full-load amps $\times$ rated voltage $\times 3^{0.5}$).

Equation 6.3–1

6.3.3.4 Motor horsepower rating shall not exceed 125% of the calculated maximum load being served, or the next larger standard motor size if a standard rating does not fall within this range.

6.3.4 Operation and Maintenance of Electrical Systems

6.3.4.1 The designer shall specify that building owners be provided with written information that provides basic data relating to the design, operation, and maintenance of the electrical distribution system for the building. This shall include:

6.3.4.1.1 a single-line diagram of the ''as-built'' building electrical system;

6.3.4.1.2 schematic diagrams of electrical control systems (other than HVAC, covered elsewhere);

6.3.4.1.3 manufacturers' operating and maintenance manuals on active electrical equipment; and

6.3.4.1.4 the Transformer Loss Calculation Estimate if required by Section 6.3.2.2.

§ 435.107 Heating, Ventilation, and Air-Conditioning (HVAC) systems.

7.1 General

7.1.1 This section contains minimum and prescriptive requirements for the design of HVAC systems. It is recommended that the designer evaluate other energy conservation measures that may be applicable to the proposed design.

7.1.2 A building shall be considered in compliance with this section if the following conditions are met:

7.1.2.1 The minimum requirements of Section 7.3 are met; and

7.1.2.2 The HVAC system design complies with the prescriptive criteria of section 7.4. For the design of HVAC systems that incorporate innovative or alternate design strategies, the compliance paths set forth in Section 11.0 or 12.0 should be used.

7.2 Principles of Design

7.2.1 Control of Equipment Loads

7.2.1.1 The thermal impact of equipment and appliances shall be minimized by use of hoods, radiation shields, or other confining techniques, and by use of controls to assure that such equipment is turned off when not needed. In addition, major heat-generating equipment shall, where practical, be located where it can balance other heat losses. For example, computer centers or kitchen areas could be located in the north or northwest perimeter areas of buildings depending on climate and prevailing wind directions. In addition, heat recovery shall be specifically considered for this equipment.

7.2.2 HVAC System Design

7.2.2.1 Separate HVAC systems shall be considered to serve areas expected to operate on widely differing operating schedules or design conditions. For instance, systems serving office areas should generally be separate from those serving retail areas. When a single system serves a multi-tenant building, provisions shall be made to shut-off or set-back the heating and cooling to each area independently.

7.2.2.2 Spaces with relatively constant and weather-independent loads may be served with systems separate from those serving perimeter spaces. Areas with special temperature or humidity requirements, such as computer rooms, shall be served by systems separate from those serving areas that require comfort heating and cooling only, alternatively, these areas shall be served by supplementary or auxiliary systems.

7.2.2.3 The supply of zone cooling and heating shall be sequenced to prevent the simultaneous operation of heating and cooling systems for same space. Where this is not possible due to ventilation or air circulation requirements, air quantities shall be reduced as much as possible before reheating, recooling, or mixing hot and cold air streams. Finally, supply air temperature shall be reset to extend economizer operations and to reduce reheat, recool, or mixing losses.

7.2.2.4 Systems serving areas with significant internal heat gains (lighting, equipment, and people), especially interior zones with little or no exposure to outside air, shall be designed to take advantage of mild or cool weather conditions to reduce cooling energy if heat recovery systems are not used. These systems, called air or water economizers, shall be designed to provide a partial reduction in cooling loads even when mechanical cooling must be used to provide the remainder of the load. Economizer controls shall be integrated with the mechanical cooling (leaving air temperature) controls so that mechanical cooling is only operated when necessary and so supply air is not overcooled to a temperature below the desired supply temperature. The systems and controls shall be designed so that economizer operation does not increase heating energy use. For instance, single fan dual duct or multizone systems that use the same mixed air plenum for both heating and cooling supplies shall not be used.

7.2.2.5 Controls shall be provided to allow systems to operate in an occupied mode and an unoccupied mode. In the occupied mode, controls shall provide for a gradually changing control point as system demands change from cooling to heating. In the unoccupied mode, ventilation and exhaust systems shall be shut off if possible, and comfort heating and cooling systems shall be shut off except to maintain ''setback'' space conditions. The setback conditions shall be the minimum and maximum levels required to prevent damage to the building or its contents and provide for a reasonable morning pick-up period. Note however that night setback may not conserve energy in buildings with large amounts of thermal mass.

7.2.2.6 In areas where diurnal temperature swings and humidity levels permit, the judicious coupling of air distribution systems and building structural mass may be considered to allow the use of night-time precooling to reduce the use of day-time mechanical cooling.

7.2.2.7 High ventilation, such as in hospital operating rooms, can impose enormous heating and cooling loads on HVAC equipment. In these cases, consideration shall be given to the use of recirculating filtered and cleaned air, rather than 100% outside air, and preheating outside air with solar systems or reclaimed heat from other sources.

7.2.3 Energy Transport Systems

7.2.3.1 Energy shall be transported by the most energy efficient means possible. The following options, are listed in order of efficiency from the (most efficient) lowest energy transport burden to the highest:

7.2.3.1.1 Electric Wire or Fuel Pipe,

7.2.3.1.2 Two-Phase Fluid Transfer (Steam or Refrigerant),

7.2.3.1.3 Single-Phase Liquid Fluid (Water, Glycol, Etc.), and

7.2.3.1.4 Air.

7.2.3.2 The distribution system shall be selected to complement other system parameters such as control strategies, storage capabilities, and conversion and utilization system efficiencies.

7.2.3.3 Steam Systems

7.2.3.3.1 Provisions for seasonal or ''non-use time'' shutdown shall be incorporated.

7.2.3.3.2 The venting of steam and ingestion of air shall be minimized with the design directed toward full vapor performance.

7.2.3.3.3 Subcooling shall generally be prevented.

7.2.3.3.4 Condensate shall be returned to boilers or source devices at the highest possible temperature.

7.2.3.4 Water Systems

7.2.3.4.1 Design flow quantity shall be minimized by designing for the maximum practical temperature differential.

7.2.3.4.2 Flow quantity shall be varied with load where possible.

7.2.3.4.3 Designs shall be for lowest practical pressure rise (or drop).

7.2.3.4.4 Operating and idle control modes shall be provided.

7.2.3.4.5 When locating equipment, the critical pressure path shall be identified and the runs sized for minimum practical pressure drop.

7.2.3.5 Air Systems

7.2.3.5.1 Air flow quantity shall be minimized by careful load analysis and an effective distribution system. If the psychometric nature of the application allows, the supply air quantity shall vary with the sensible load (i.e., VAV systems). The fan pressure requirement shall be held to the lowest practical value. Fan pressure shall be avoided as a source for control power.

7.2.3.5.2 Each fan system shall be designed and controlled to reduce mechanical cooling requirements by taking advantage of favorable weather conditions.

7.2.3.5.3 ''Normal'' and ''idle'' control modes shall be provided for the fan systems as well as the psychometric systems.

7.2.3.5.4 Duct run distances shall be as short as possible, and the runs on the critical pressure path sized for minimum practical pressure drop.

7.2.4 Radiant Heating

7.2.4.1 Radiant heating systems shall be considered in lieu of convective or all-air heating systems to heat areas which experience infiltration loads in excess of two (2) air changes per hour at design heating conditions.

7.2.4.2 Radiant heating systems should be considered for areas with high ceilings, for spot heating, and for other applications where radiant heating may be more energy efficient than convective or all-air heating systems.

7.2.5 Energy Recovery

7.2.5.1 Systems that recover energy should be considered when rejected fluid is of adequate temperature and a simultaneous need for energy exists for a significant number of operating hours.

7.3 Minimum Requirements

7.3.1 Calculation Procedures

7.3.1.1 Heating and cooling system design loads for the purpose of sizing systems and equipment shall be determined in accordance with the procedures described in the *ASHRAE Handbook, 1985 Fundamentals Volume,* or a similar computation procedure. The design parameters specified in sections 7.3.1.2 through 7.3.1.10 shall be used for calculational purposes only and are not requirements or recommendations for operating setpoints.

7.3.1.2 *Indoor Design Conditions.* Indoor design temperature and humidity conditions for general comfort applications shall be in accordance with the comfort criteria established in *ANSI/ASHRAE Standard 55–1981,* ''Thermal Environmental Conditions for Human Occupancy,'' and/or Chapter 8 of the *ASHRAE Handbook, 1985 Fundamentals Volume,* except that winter humidification and summer dehumidification are not required.

7.3.1.2.1 *Exceptions to Section 7.3.1.2:*

(a) Health care institutions and similar facilities where the indoor conditions may not be appropriate for the health and safety of occupants; and

(b) Where special room temperature and/or humidity conditions are required by a process or procedure, other than comfort, such as rooms used for surgery or data processing.

7.3.1.3 *Outdoor Design Conditions.* Outdoor design conditions shall be selected for listed locations from the *ASHRAE Handbook, 1985 Fundamentals Volume,* from the columns of 99% values for heating design and 2.5% values for cooling design. Local weather data from the National Weather Service of the National Oceanic and Atmospheric Administration based on the same 99% and 2.5% values (or statistically similar annualized values such as 0.2% winter and 0.5% summer) may be used.

7.3.1.3.1 *Exception to Section 7.3.1.3:*

(a) Where necessary to assure the prevention of damage to the building or to material and equipment within the building, the median of annual extremes for heating and 1% column for cooling may be used.

7.3.1.4 *Ventilation.* Outdoor air ventilation rates shall be selected from section 6.1 of *ASHRAE Standard 62–1981,* ''Ventilation for Acceptable Indoor Air Quality.''

7.3.1.4.1 *Exception to Section 7.3.1.4:*

(a) Outdoor air quantities, exceeding those shown in *ASHRAE Standard 62–1981,* required because of special occupancy or process requirements, source control of air contamination, or local codes.

7.3.1.5 *Infiltration.* Infiltration for heating and cooling design loads shall be calculated by the procedures in the *ASHRAE Handbook, 1985 Fundamentals Volume,* or a similar computation procedure.

7.3.1.6 *Envelope.* Building envelope heating and cooling loads shall be based on envelope characteristics, such as thermal conductance, shading coefficient and air leakage, consistent with the values used in the proposed building design to demonstrate compliance with section 5.0.

7.3.1.7 *Lighting.* Lighting loads shall be based on proposed design lighting levels or power budgets consistent with section 3.0. Lighting may be ignored for heating load calculations.

7.3.1.8 *Other Loads.* Other HVAC system loads, such as those due to people and equipment, shall be based on design data compiled from at least one of the following sources:

7.3.1.8.1 Actual information based on the intended use of the building;

7.3.1.8.2 Published data from manufacturers' technical publications and from technical society publications such as the *ASHRAE Handbook, 1987 HVAC Systems Applications Volume;*

7.3.1.8.3 Alereza, ''Estimates of Recommended Heat Gains Due to Commercial Appliances and Equipment,'' *ASHRAE Transactions 90 (Pt. 2A), 25–28* (1984);

7.3.1.8.4 Default values to be used in determining the design energy budget in section 11.0 or 12.0 taken from Tables 11–2, 11–3, 11–4 and 11–6; and

7.3.1.8.5 Other data based on designer's experience of expected loads and occupancy patterns.

7.3.1.8.6 *Exception to Section 7.3.1.8:*

(a) Internal heat gains may be ignored for heating load calculations.

7.3.1.9 *Safety Factor.* Design loads may, at the designer's option, be increased by as much as 10% to account for unexpected loads or changes in space usage.

7.3.1.10 *Pick-up Loads.* Transient loads such as warm-up or cool-down loads that occur after off-hour setback or shutoff, may be calculated from basic principles, based on the heat capacity of the building and its contents, the degree of setback, and desired recovery time, or may be assumed to be up to 30% for heating and 10% for cooling of the steady-state design loads.

7.3.2 System and Equipment Sizing

7.3.2.1 HVAC systems and equipment shall be sized to provide no more than the space and system loads require, as calculated in accordance with section 7.3.1.

7.3.2.1.1 *Exceptions to Section 7.3.2.1:*

(a) Equipment capacity may exceed the design load if the equipment selected is the smallest size needed to meet the load within available options of equipment;

(b) Equipment whose capacity exceeds the design load may be specified if calculations demonstrate that oversizing can be shown not to increase annual energy use;

(c) Stand-by equipment may be installed if controls and devices are provided that allow stand-by equipment to operate automatically only when the primary equipment is not operating;

(d) Multiple units of the same equipment type, such as multiple chillers and boilers, with combined capacities exceeding the design load may be specified to operate concurrently only if controls are provided that sequence or otherwise optimally control the operation of each unit based on cooling or heating load;

(e) For unitary equipment with both heating and cooling capability, only one function, either the heating or the cooling, need meet the requirements of this subsection. Capacity for the other function shall be, within available equipment options, the smallest size necessary to meet the load; and

(f) For buildings complying with section 11.0 or 12.0, equipment of higher capacity than the design load may be specified if the oversized equipment is modeled in the building energy analysis of the proposed design and the proposed design complies with the standards.

7.3.3 Separate Air Distribution Systems

7.3.3.1 Zones in a building that are expected to operate non-concurrently for 750 or more hours per year shall either be served by separate air distribution systems, or off-hour controls shall be provided in accordance with section 7.3.5.3.

7.3.3.2 Zones with special process temperature and/or humidity requirements shall be served by separate air distribution systems from those serving zones requiring only comfort heating and/or cooling, or supplementary provisions shall be included to allow the primary systems to be specifically controlled for comfort purposes only.

7.3.3.2.1 *Exception to Section 7.3.3.2:*

(a) Zones, requiring comfort heating and/or cooling, that are served by a system primarily used for process temperature and humidity control, need not be served by a separate system if the total supply air to these zones is no more than 25% of the total system supply air, or the zones total conditioned floor area is less than 1000 ft^2.

7.3.3.3 Zones having substantially different heating or cooling load characteristics, such as perimeter zones in contrast to interior zones, shall not be served by a single multiple zone air distribution system.

7.3.4 Temperature Controls

7.3.4.1 *System Control.* Each HVAC system shall include at least one temperature control device.

7.3.4.2 *Zone Controls.* The supply of heating and/or cooling energy to each zone shall be controlled by an individual thermostat located within the zone.

7.3.4.2.1 *Exceptions to Section 7.3.4.2:*

(a) Independent perimeter systems may serve multiple zones of the primary/interior system with the following limitations:

(1) The perimeter system shall include at least one thermostatic control zone for each major building exposure having exterior walls facing only one orientation for 50 contiguous feet or more; and

(2) The perimeter system heating and/or cooling supply shall be controlled by thermostat controls located within the zone(s) served by the system; and

(b) A dwelling unit may be considered a single zone.

7.3.4.3 Zone thermostats used to control comfort heating shall be capable of being set, locally or remotely, by adjustment or selection of sensors, down to 55 °F.

7.3.4.4 Zone thermostats used to control comfort cooling shall be capable of being set, locally or remotely, by adjustment or selection of sensors, up to 85 °F.

7.3.4.5 Zone thermostats used to control both heating and cooling shall be capable of providing a temperavure range or dead band of at least 5 °F within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum.

7.3.4.5.1 *Exceptions to Section 7.3.4.5:*

(a) For buildings complying with Section 11.0 or 12.0, dead band controls are not required if, in the building energy analysis, heating and cooling thermostat setpoints are set to the same value between 70 °F and 75 °F and assumed to be constant throughout the year;

(b) Special occupancy, special usage or construction code requirements where dead band controls are not appropriate, adjustable single setpoint thermostats may be used; and

(c) Thermostats that require manual changeover between heating and cooling modes.

7.3.5 Off-hour Controls

7.3.5.1 Each HVAC system shall have automatic control setback and/or shutdown of equipment during periods of non-use or alternate use of the spaces served by the system.

7.3.5.1.1 *Exceptions to Section 7.3.5.1:*

(a) Systems serving areas expected to operate continuously;

(b) Where equipment with a full load demand of 2kW (6826 Btu/h) or less may be controlled by readily accessible manual off-hour controls;

(c) Where setback or shutdown will not result in a decrease in overall building energy use.

7.3.5.2 Outside air supply and/or exhaust systems shall be equipped with motorized or gravity dampers or other means of automatic volume shutoff or reduction during periods of non-use or alternate use of the spaces served by the system.

7.3.5.2.1 *Exceptions to Section 7.3.5.2:*

(a) Individual ventilation systems when design air flow is 3000 cfm or less;

(b) Systems that operate continuously;

(c) When restricted by code, such as at combustion air intakes; or

(d) When gravity and other non-electrical ventilation systems may be controlled by readily accessible manual damper controls.

7.3.5.2.2 Dampers may be required in some climates to prevent equipment damage due to freezing and/or to provide proper warm-up control.

7.3.5.3 Systems that serve areas that operate non-concurrently for 750 or more hours per year shall have isolation devices and controls for shut off or set back of heating and cooling to each zone independently. Isolation is not required for zones expected to operate continuously or expected to be inoperative only when all other zones are inoperative.

7.3.5.3.1 For buildings where occupancy patterns are not known at the time of system design, isolation areas may be predesignated.

7.3.5.3.2 Zones may be grouped into a single isolation area providing the total conditioned floor area does not exceed 25,000 ft^2 per group nor include more than one floor.

7.3.6 Humidity Control

7.3.6.1 If a system maintains specific relative humidities by adding moisture, a humidistat shall be provided.

7.3.6.2 If comfort humidification is provided, the system shall be designed to prevent the use of fossil fuel or electricity to maintain relative humidity in excess of 30%.

7.3.6.3 If comfort dehumidification is provided, the system shall be designed to prevent the use of fossil fuel or electricity to reduce relative humidity below 60%.

7.3.7 Materials and Construction

7.3.7.1 Insulation required by section 7.3.7.2 and 7.3.7.3 shall be suitably protected from damage. Insulation shall be installed in accordance with the *Midwest Insulation Contractors Association ''Commercial and Industrial Insulation Standards,''* 1983.

7.3.7.2 *Piping Insulation*. All HVAC system piping installed to serve buildings and within buildings shall be thermally insulated in accordance with Table 7.3–1.

Table 7.3-1
Minimum Pipe Insulation (In.)[1]

Fluid Design Operating Temperature Range, °F	Insulation Conductivity		Nominal Pipe Diameter (In.)					
	Conductivity Range Btu·in./F·h·ft²	Mean Rating Temperature °F	Runouts[2] up to 2	1 and less	1-1/4 to 2	2-1/2 to 4	5 & 6	8 and up
Heating Systems (Steam, Steam Condensate, & Hot Water)								
351-450	0.32-0.34	250	1.5	2.5	2.5	3.0	3.5	3.5
251-350	0.29-0.31	200	1.5	2.0	2.5	2.5	3.5	3.5
201-250	0.27-0.30	150	1.0	1.5	1.5	2.0	2.0	3.5
141-200	0.25-0.29	125	0.5	1.5	1.5	1.5	1.5	1.5
105-140	0.24-0.28	100	0.5	1.0	1.0	1.0	1.5	1.5
Domestic and Service Hot Water Systems[3]								
105-140	0.24-0.28	100	0.5	1.0	1.0	1.5	1.5	1.5
Cooling Systems (Chilled Water, Brine, & Refrigerant)[4]								
40-55	0.23-0.27	75	0.5	0.5	0.75	1.0	1.0	1.0
Below 40	0.23-0.27	75	1.0	1.0	1.5	1.5	1.5	1.5

1. For minimum thicknesses of alternative insulation types, see Section 7.3.7.2.2.
2. Runouts to individual terminal units not exceeding 12 ft in length.
3. Applies to recirculating sections of service or domestic hot water systems and first 8 ft from storage tank for non-recirculating systems.
4. The required minimum thicknesses do not consider water vapor transmission and condensation. Additional insulation and/or vapor retarders may be required to limit water vapor transmission and condensation.

7.3.7.2.1 *Exceptions to Section 7.3.7.2:*

(a) For manufacturer installed piping within HVAC equipment tested and rated in accordance with Section 8.3;

(b) For piping conveying fluids at temperatures between 55 °F and 105 °F;

(c) For piping conveying fluids that have not been heated or cooled through the use of fossil fuels or electricity; and

(d) When calculations demonstrate that heat gain and/or heat loss to or from piping without insulation will not increase building energy use.

7.3.7.2.2 *Alternative Insulation Types.* Insulation thicknesses in Table 7.3–1 are based on insulation with thermal conductivities listed in Table 7.3–1 for each fluid operating temperature range, rated in accordance with *ASTM C 335–84,* ''Test Method for Steady-State Heat Transfer Properties of Horizontal Pipe Insulations,'' at the mean temperature listed in the table. For insulating materials having conductivities more than of those shown in the Table 7.3–1 for the applicable fluid operating temperature range and at the mean rating temperature shown, when rounded to the nearest 1/100th Btu/h•°F•ft², the minimum thickness shall be determined in accordance with Equation 7.3–1:

$$T = PR \times [(1 + t/PR)^{K}/k - 1]$$

Equation 7.3–1

Where:

T=minimum insulation thickness for material with conductivity K, in.
PR=pipe actual outside radius, in.
t=insulation thickness from Table 7.3–1, in.
K=conductivity of alternate material at the mean rating temperature indicated in Table 7.3–1 for the applicable fluid temperature range, Btu• in./h•°F•ft ^{2}
k=the lower value of conductivity listed in Table 7.3–1 for the applicable fluid temperature range, Btu• in./h•°F•ft ^{2}

7.3.7.3 *Air Handling System Insulation*. All air handling ducts, plenums, and other enclosures installed as part of an HVAC air distribution system shall be thermally insulated in accordance with Table 7.3–2 (This table comes from section 1005 of the 1985 Uniform Mechanical Code).

Table 7.3-2
Minimum Duct Insulation

Duct Location	Cooling[2]		Heating[3]	
	Annual Cooling Degree Days Base 65 °F	Insulation R-value[4] ft^2·h·°F/Btu	Annual Heating Degree Days Base 65 °F	Insulation R-value[4] ft^2·h·°F/Btu
Exterior of building	below 500	3.3	below 1500	3.3
	500 to 1150	5.0	1500 to 4500	5.0
	1151 to 2000	6.5	4501 to 7500	6.5
	above 2000	8.0	above 7500	8.0
Inside of building envelope or in unconditioned spaces[7]				
TD[5] <=15		None Requ'd		None Req'd
40 >= TD[5] > 15	----	3.3	----	3.3
TD[5] > 40	----	5.0[6]	----	5.0[6]

1. Insulation R-values shown are for the insulation as installed and do not include film resistance. The required minimum thicknesses do not consider water vapor transmission and condensation. Additional insulation and/or vapor retarders may be required to limit vapor transmission and condensation. For ducts which are designed to convey both heated and cooled air, duct insulation shall be as required by the most restrictive condition. Where exterior walls are used as plenum walls, wall insulation shall be as required by the most restrictive condition of this Section or Section 5.0.
2. Cooling ducts are those designed to convey mechanically heated air or return ducts in such systems.
3. Heating ducts are those designed to convey mechanically heated air or return ducts in such systems.
4. Insulation resistance measured on a horizontal plane in accordance with ASTM C518-85 at a mean temperature of 75 °F at the installed insulation thickness.
5. TD is defined as the temperature difference at design conditions (see Section 7.3.1) between the space within which the duct is located and the design air temperature in the duct.
6. Insulation resistance for runnouts to terminal devices less than 10 feet in length need not exceed 3.3 ft^2·h·F/Btu.
7. Unconditioned spaces include crawl spaces and attics.

7.3.7.3.1 *Exception to section 7.3.7.3:* Duct insulation is not required in any of the following cases:

(a) Manufacturer installed plenums, casings or ductwork furnished as a part of HVAC equipment tested and rated in accordance with section 8.3; and

(b) When calculations demonstrate that heat gain and/or heat loss to or from ducts without insulation will not increase building energy use.

7.3.7.4 *Duct Construction.* All air handling ductwork and plenums shall be constructed, erected and tested in accordance with the following Sheet Metal and Air Conditioning Contractors National Association (SMACNA) Standards: *HVAC Duct System Design Manual,* 1986; *HVAC Duct Leakage Test Manual,* 1985; and *Fibrous Glass Construction Standards,* 5th edition, 1979.

7.3.7.4.1 Ductwork designed to operate at static pressure differences greater than 3 in. W.C. shall be leak tested and conform with the following requirements of the *HVAC Duct Leakage Manual, 1985:* Test procedures shall be in accordance with those outlined in section 5.0 of the manual, or equivalent; test reports shall be provided in accordance with section 6.0 of the manual, or equivalent; the tested duct leakage class at a test pressure equal to the design duct pressure class rating shall be equal to or less than leakage class 6 as defined in section 4.1 of the manual. Leakage testing may be limited to representative sections of the duct system but in no case shall such tested sections include less than 25% of the total installed duct area for the designated pressure class.

7.3.7.4.2 Where supply ductwork designed to operate at static pressure differences from ¼ in. to 2 in. W.C. are located outside of the conditioned space, including return plenums, joints shall be sealed in accordance with Seal Class C, as defined in the SMACNA manuals referenced above. Pressure sensitive tape shall not be used as the primary sealant for such ducts designed to operate at 1 in. W.C. pressure difference or greater.

7.3.8 Completion Requirements

7.3.8.1 An operating and maintenance manual shall be provided to the building owner. The manual shall include basic data relating to the operation and maintenance of HVAC systems and equipment. Required routine maintenance actions shall be clearly identified. Where applicable, HVAC controls information such as diagrams, schematics, control sequence descriptions, and maintenance and calibration information shall be included.

7.3.8.2 Air system balancing shall be accomplished in a manner to minimize throttling losses and then fan speed shall be adjusted to meet design flow conditions. Balancing procedures shall be in accordance with those established by the National Environmental Balancing Bureau (NEBB), the Association of Air Balancing Council (AABC), or similar procedures.

7.3.8.2.1 *Exception to section 7.3.8.2:*

(a) Damper throttling may be used for air system balancing with fan motors of 1 hp or less, or if throttling results in no greater than ⅓ hp fan horsepower draw above that required if the fan speed were adjusted.

7.3.8.3 Hydronic system balancing shall be accomplished in a manner to minimize throttling losses and then the pump impeller shall be trimmed or pump speed shall be adjusted to meet design flow conditions.

7.3.8.3.1 *Exceptions to section 7.3.8.3:* Valve throttling may be used for hydronic systems balancing under any of the following conditions:

(a) Pumps with pump motors of 10 hp and less;

(b) If throttling results in pump horsepower draw no greater than 3 hp above that required if the impeller were trimmed;

(c) To reserve additional pump pressure capability in open circuit piping systems subject to fouling. Valve throttling pressure drop shall not exceed that expected for future fouling; or

(d) Where it can be shown that throttling will not increase overall building energy use.

7.3.8.4 HVAC control systems shall be tested to assure that control elements are calibrated, adjusted, and in proper working condition.

7.4 Heating, Ventilation and Air-Conditioning (HVAC) Systems—Prescriptive Compliance Alternative

7.4.1 Zone Controls

7.4.1.1 Zone thermostatic and humidistatic controls shall be capable of operating in sequence, the supply of heating and cooling energy to the zone. The controls shall prevent:

7.4.1.1.1 Reheating (heating air that is cooler than system mixed air);

7.4.1.1.2 Recooling (cooling air that is warmer than system mixed air);

7.4.1.1.3 Mixing or the simultaneous supply of air that has been previously mechanically heated and air that has been previously cooled, either by mechanical refrigeration or by economizer systems; and

7.4.1.1.4 Other simultaneous operation of heating and cooling systems to one zone.

7.4.1.2 *Exceptions to section 7.4.1.1:*

7.4.1.2.1 Variable air volume systems that, during periods of occupancy, are designed to reduce the air supply to each zone to a minimum before reheating, recooling, or mixing during periods of occupancy. The minimum volume setting shall be no greater than the larger of the following:

(a) 30% of the peak supply volume;

(b) The minimum volume required to meet the ventilation requirements of section 7.3.1.4; and

(c) 0.4 cfm/ft^2 of conditioned zone area. In addition, supply air temperatures shall be automatically reset based on representative building loads or outside air temperature by at least 25% of the difference between the design supply air and room air temperature. Zones expected to experience relatively constant loads, such as interior zones, shall be designed for the fully reset supply temperature. Supply air reset control is not required if calculations demonstrate that it increases overall building energy use;

7.4.1.2.2 Zones where special pressurization relationships or cross-contamination requirements are such that variable air volume systems are impractical, such as some areas of hospitals and laboratories. In these cases, systems shall include automatic supply air reset controls in accordance with section 7.4.1.2.1 above;

7.4.1.2.3 At least 75% of the energy for reheating or providing warm air in mixing systems is provided from site-recovered energy that would otherwise be wasted, or from non-depletable energy sources;

7.4.1.2.4 Zones where specific humidity levels are required to satisfy process needs, such as computer rooms and museums (see section 7.3.3.2); and

7.4.1.2.5 Zones with a peak supply air quantity of 300 cfm or less.

7.4.2 Economizer Controls

7.4.2.1 Each fan system shall be designed to take advantage of favorable weather conditions to reduce mechanical cooling requirements. The system shall include either of the following:

7.4.2.1.1 A temperature or enthalpy air economizer system that is capable of automatically modulating outside air and return air dampers to provide up to 85% outside air for cooling; or

7.4.2.1.2 A water economizer system that is capable of cooling supply air by direct and/or indirect evaporation. The system shall be designed and controlled to be able to provide 100% of the system cooling load at outside air temperatures of 50 °F dry-bulb/45 °F wet-bulb and below. Each economizer system shall be capable of providing partial cooling even when additional mechanical cooling is required to meet the remainder of the cooling load.

7.4.2.1.3 *Exceptions to section 7.4.2.1:*

(a) individual fan/cooling units with supply capacity of less than 3,000 cfm or a total cooling capacity less than 90,000 Btu/h. The total capacity of such units per building complying by this exception shall not exceed 600,000 Btu/h per building or 10% of the total installed cooling capacity, whichever is larger;

(b) Systems with air or evaporatively cooled condensers and for which one of the following is true:

(1) The system is located where the quality of the air, as defined in *ASHRAE Standard 62–1981*, is so poor as to require extensive treatment of the air, and

(2) Calculations indicate that the use of outdoor air cooling affects the operation of other systems, such as humidification, dehumidification, and supermarket refrigeration systems and will increase overall building energy use;

(c) Calculations demonstrate that the overall building energy use for alternative designs, such as internal/external zone heat recovery systems, are less than those for an economizer system;

(d) The system is located where the outdoor summer wet-bulb design condition (2.5% occurrence, *ASHRAE Handbook, 1985 Fundamentals Volume)* is more than 72 °F and annual HDD65 are less than 2,000;

(e) Systems that serve envelope dominated spaces whose design space sensible cooling load, excluding transmission and infiltration loads, is less than or equal to transmission and infiltration losses at an outdoor temperature of 60 °F;

(f) Systems serving residential spaces including hotel/motel rooms;

(g) Cooling systems for which 75% of its annual energy consumption is provided by site-recovered energy that would otherwise be wasted, or from non-depletable energy sources; and

(h) The zone(s) served by the system each have operable openings (windows, doors, etc.), the openable area of which is greater than 5% of the conditioned floor area. This exception applies only to spaces open to and within 20 ft of the operable openings. Automatic controls shall be provided that lockout system mechanical cooling when outdoor air temperatures are less than 60 °F.

7.4.2.2 Economizer systems shall be capable of providing partial cooling even when additional mechanical cooling is required to meet the remainder of the cooling load.

7.4.2.2.1 *Exceptions to section 7.4.2.2.*

(a) Direct expansion systems may include controls to reduce the quantity of outside air as required to prevent coil frosting at the lowest step of compressor unloading. Individual direct expansion units that have a cooling capacity of 180,000 Btu/h or less may use economizer controls that preclude economizer operation whenever mechanical cooling is required simultaneously; and

(b) Systems in climates with less than 750 average hours per year between 8 a.m. and 4 p.m. when the ambient dry bulb temperatures are between 55 °F and 69 °F inclusive. See Attachment 5A for climate data for 234 U.S. cities.

7.4.2.3 System design and economizer controls shall be such that economizer operation does not increase the building heating energy use during normal operation.

7.4.2.3.1 *Exception to section 7.4.2.3:*

(a) At least 75% of the energy for heating is provided from site-recovered energy that would otherwise be wasted, or from non-depletable energy sources.

7.4.3 Fan System Design Requirements.

7.4.3.1 The following design criteria apply to all HVAC fan systems used for comfort heating, ventilating and/or cooling. For the purposes of this subsection, the energy demand of a fan is the sum of the demand of all fans that are required to operate at design conditions to supply air from the heating and/or cooling source to the conditioned space(s) and return it back to the source or exhaust it to the outdoors.

7.4.3.1.1 *Exceptions to section 7.4.3.1:*

(a) Systems with total fan system motor horsepower of 10 hp or less;

(b) Unitary equipment for which the energy used by the fan is considered in the efficiency ratings of Section 8.0; and

(c) Total fan energy demand need not include the additional power required by air treatment or filtering systems with final pressure drops in excess of 1 in. W.C.

7.4.3.2 Constant Volume Fan Systems.

7.4.3.2.1 For supply and return fan systems that provide a constant air volume whenever the fans are operating, the power required for the combined fan system at design conditions shall not exceed 0.8 W/cfm of supply air.

7.4.3.3 Variable Air Volume (VAV) Fan Systems.

7.4.3.3.1 For supply and return fan systems that vary system air volume automatically as a function of load, the power required by the motors for the combined system at design conditions shall not exceed 1.25 W/cfm.

7.4.3.3.2 Individual VAV fans with motors 75 hp and larger shall include controls and devices necessary for the fan motor to control demand to no more than 50% of design wattage at 50% of design air volume, based on manufacturer's test data.

7.4.4 Pumping System Design Criteria.

7.4.4.1 The following design criteria apply to all HVAC pumping systems used for comfort heating and/or cooling. For the purposes of this section, the energy demand of a pumping system is the sum of the demand of all pumps that are required to operate at design conditions to supply fluid from the heating and/or cooling source to the conditioned space(s) or heat transfer device(s) and return it to the source.

7.4.4.1.1 *Exception to section 7.4.4.1:*

(a) Systems with total pump system motor horsepower of 10 hp or less.

7.4.4.2 *Friction Rate.* Piping systems shall be designed at a design friction pressure loss rate of no more than 4.0 ft of water per 100 equivalent ft of pipe. Lower friction rates may be required for proper noise or corrosion control.

7.4.4.3 *Variable Flow.* Pumping systems that serve control valves designed to modulate or step open and close as a function of load, shall be designed for variable fluid flow. The system shall be capable of reducing flow to 50% of design flow or less. Flow may be varied by one of several methods, including, but not limited to, variable speed driven pumps, staged multiple pumps, or pumps riding their characteristic performance curves.

7.4.4.3.1 *Exceptions to section 7.4.4.3:*

(a) Systems where a minimum flow greater than 50% of the design flow is required for the proper operation of equipment served by the system, such as chillers;

(b) Systems that serve no more than one control valve;

(c) Where the overall building energy use resulting from an alternative design, such as a constant flow/variable temperature pumping system, is no more than those from a variable flow system; and

(d) Systems that include supply temperature reset controls in accordance with section 7.4.5.2 without exception.

7.4.5 System Temperature Reset Controls.

7.4.5.1 *Air Systems.* Systems supplying heated or cooled air to multiple zones shall include controls that automatically reset supply air temperatures by representative building loads or by outside air temperature. Temperature shall be reset by at least 25% of the design supply-air-to-room-air temperature difference. Zones that are expected to experience relatively constant loads, such as interior zones, shall be designed for the fully reset supply temperature.

7.4.5.1.1 *Exceptions to section 7.4.5.1:*

(a) Systems which comply with section 7.4.1 without using exceptions in sections 7.4.1.2.1 or 7.4.1.2.2; and

(b) Where it can be shown that supply air temperature reset increases overall building annual energy costs.

7.4.5.2 *Hydronic Systems.* Systems supplying heated and/or chilled water to comfort conditioning systems shall include controls that automatically reset supply water temperatures by representative building loads (including return water temperature) or by outside air temperature. Temperature shall be reset by at least 25% of the design supply-to-return water temperature difference.

7.4.5.2.1 *Exceptions to section 7.4.5.2:*

(a) Systems that comply with section 7.4.4.3 without exception;

(b) Where it can be shown that supply temperature reset increases overall building annual energy use;

(c) Systems for which supply temperature reset controls cannot be implemented without causing improper operation of heating, cooling, humidification, or dehumidification systems; or

(d) Systems with less than 600,000 Btu/h design capacity.

§ 435.108 Heating, ventilation and air-conditioning (HVAC) equipment.

8.1 General

8.1.1 This section contains minimum requirements for fundamental to good practice and/or the minimum acceptable state-of-the-art in energy efficient HVAC equipment.

8.1.2 A building shall be considered in compliance with this section if the minimum requirements of Section 8.3 are met.

8.2 Principles of Design

8.2.1 The rate of energy input(s) and the heating or cooling output(s) of all HVAC products shall be ascertained. This information shall be based on equipment in new condition, and shall cover full load, partial load, and standby conditions. The information shall also include performance data for modes of equipment operation and at ambient conditions as specified in the minimum equipment performance requirements below.

8.2.2 Source Systems

8.2.2.1 To allow for HVAC equipment operation at the highest efficiencies, conversion devices shall be matched to load increments, and operation of modules shall be sequenced. Oversized or large scale systems shall never be used to serve small seasonal loads (e.g., a large heating boiler to serve a summer service water heating load). Specific ''low load'' units shall be incorporated in the design where prolonged use at minimal capacities is expected.

8.2.2.2 Storage techniques should be used to level or distribute loads that vary on a time or spatial basis to allow operation of a device at maximum (full-load) efficiency.

8.2.2.3 All equipment shall be the most efficient (or highest COP) practical, at both design and reduced capacity (part-load) operating conditions.

8.2.2.4 Fluid temperatures for heating equipment shall be as low as practical and for cooling equipment as high as practical, while meeting loads and minimizing flow quantities.

8.3 Minimum Requirements

8.3.1 Equipment Efficiency

8.3.1.1 *Minimum Equipment Efficiency*. Equipment shall have a minimum efficiency at the specified rating conditions, not less than the values shown in Tables 8.3–1 through 8.3–10. Minimum efficiencies for equipment using chlorofluorocarbons (CFCs) refrigerants reflect the assumption that the use of certain refrigerants may be restricted because of ozone layer depletion concerns.

8.3.1.2 Data furnished by the equipment supplier or certified under a nationally-recognized certification program or rating procedure may be used to satisfy these requirements.

8.3.1.3 Integrated Part-Load Value (IPLV) is the descriptor for part-load efficiency for certain types of equipment. The IPLVs are found in the referenced ARI Standards. Compliance with minimum efficiency requirements specified for certain HVAC equipment shall include compliance with part-load requirements as well as standard or full-load requirements.

8.3.1.4 If nationally-recognized test procedures for combined equipment are not available, efficiencies for service water heating shall be determined using data provided by equipment and component manufacturers, employing reasonable assumptions concerning uncertain parameters.

8.3.1.5 Omission of minimum performance requirements for certain classes of HVAC equipment does not preclude use of such equipment where appropriate.

8.3.2 Field Assembled Equipment and Components

8.3.2.1 Where components, such as indoor or outdoor coils, from more than one manufacturer are used as parts of a cooling or heating unit, it shall be the responsibility of the system designer to specify component efficiencies, which when combined will provide equipment that is in compliance with the requirements of these standards, based on data provided by the component manufacturers.

8.3.2.2 Total on-site energy input to the equipment shall be determined by combining the energy inputs to all components, elements, and accessories including but not limited to compressor(s), internal circulating pump(s), condenser-air fan(s), evaporative-condenser cooling water pump(s), purge devices, viscosity control heaters, and controls.

8.3.2.3 *Heat-Operated Water Chilling Package.* Double-effect, heat-operated water chilling packages shall be used in lieu of single-effect equipment, due to their higher efficiency, except where the energy input is from low temperature waste-heat or non-depletable energy sources.

8.3.3 Equipment Controls

8.3.3.3 Heat pumps equipped with supplementary resistance heaters for comfort heating shall be installed with a control to prevent heater operation when the heating load can be met by the heat pump. A two-stage room thermostat, that controls the supplementary heat on its second stage, will meet this requirement. Supplementary heater operation is permitted where it can be shown that supplementary heating reduces energy use. Supplementary heater operation is permitted during short transient periods of less than 15 minutes during defrost cycles.

8.3.3.3.1 Controls shall provide a means of activating the supplementary heat source on an emergency basis and a visible indicator shall be provided to indicate the emergency heat status.

8.3.3.4 *Cooling Equipment Auxiliary Controls*. Evaporator coil frosting and excessive compressor cycling at part-load conditions shall not be controlled by use of either hot gas by-pass or evaporator pressure regulator control.

8.3.4 Comfort Heating Equipment

8.3.4.1 The designer shall obtain data and information from the manufacturer of electric resistance comfort heating equipment regarding full-load and part-load energy consumption of the heating equipment over the range of voltages at which the equipment is intended to operate. All auxiliaries required for the operation of the heater equipment such as, but not limited to fans, pumps, viscosity control heaters, fuel handling equipment, and blowers shall be included in the energy input data provided by the manufacturer(s).

8.3.5 Maintenance

8.3.5.1 Provisions shall be made to provide necessary preventive maintenance information to maintain efficient operation of all HVAC equipment.

Table 8.3-1
Standard Rating Conditions and Minimum Performance
Unitary Air Conditioners and Heat Pumps - Air-Cooled, Electrically-Operated
<135,000 Btu/h Cooling Capacity - Except Packaged Terminal and Room Air Conditioners

Reference Standards	Category	Phases	Subcategory & Rating Condition (Outdoor Temps. °F)	Minimum Performance
	<65,000 Btu/h		Seasonal Rating[1]	
ARI 210-81	Cooling Capacity	1	Split-System	10.0 SEER
ARI 240-81	Cooling Mode		Single-Package	9.7 SEER
ARI 210/ 240-84	<65,000 Btu/h		Standard Rating (95 db)	
	Cooling Capacity	3	Split-System & Single-Pkg.	9.5 EER
	Cooling Mode		Integrated Part-Load Value (80 db)	
			Split-System & Single-Pkg.	8.5 IPLV
	≥65,000 <135,000 Btu/h		Standard Rating (95 db)	8.9 EER
	Cooling Mode	All	Integrated Part-Load Value (80 db)	8.3 IPLV
	<65,000 Btu/h		Seasonal Rating[1]	
	Cooling Capacity	1	Split-Systems	6.6 HSPF
	Heating Mode (Heat Pumps)		Single-Package	6.6 HSPF
	<65,000 Btu/h		Split-System & Single Pkg.	
	Cooling Capacity	3	High Temp. Rating (47db/43wb)	3.0 COP
	Heating Mode		Low Temp. Rating (17db/15/wb)	2.0 COP
	≥65,000 <135,000 Btu/h		Split-System & Single Pkg.	
	Cooling Capacity	All	High Temp. Rating (47db/45wb)	3.0 COP
	Heating Mode		Low Temp. Rating (17db/15wb)	2.0 COP

1. To be consistent with National Appliance Energy Conservation Act of 1987 (Pub. L. 100-12)

Table 8.3-2
Standard Rating Conditions and Minimum Performance
Unity Air Conditioners and Heat Pumps - Evaporatively-Cooled, Electrically-Operated - Cooling Mode
<135,000 Btu/h Cooling Capacity - Except Packaged Terminal and Room Air Conditioners

Reference Standards	Category	Rating Condition °F Indoor Temp.	Rating Condition °F Outdoor Temp.	Minimum Performance
ARI 210-81	<65,000 Btu/h Cooling Capacity	Standard Rating 80db/67wb	95db/75wb	9.3 EER
	<65,000 Btu/h	Integrated Part-Load Value (80db/67wb)		8.5 IPLV
ARI 210/ 270-84	≥65,000 <135,000 Btu/h	Standard Rating 80db/67wb	95db/75wb	10.5 EER
CTI 201 (86)	≥65,000 <135,000 Btu/h	Integrated Part-Load Value (80db/67wb)		9.7 IPLV

Table 8.3-3
Standard Rating Conditions & Minimum Performance
Water-Cooled Air Conditioners and Heat Pumps -Cooling Mode
<135,000 Btu/h Cooling Capacity - Electrically-Operated

Reference Standard	Category	Rating Condition °F		Minimum Performance
		Indoor Air	Entering Water	
Water-Source Heat Pumps ARI 320-86 CTI 201 (86)	<65,000 Btu/h Cooling Capacity	Standard Rating		
		80db/67wb	85	9.3 EER
		Low Temperature Rating		
		80db/67wb	75	10.2 EER
	>65,000 <135,000 Btu/h Cooling Capacity	Standard Rating		
		80db/67wb	85	10.5 EER
Groundwater-Cooled Heat Pumps ARI 325-85	<135,000 Btu/h Cooling Capacity	Standard Rating		
		70 F Entering Water		11.0 EER
		Low Temperature Rating		
		50 F Entering Water		11.5 EER
Water-Cooled Unitary Air Conditioners ARI 210-81 ARI 210/240-84 CTI 201 (86)	<65,000 Btu/h Cooling Capacity	Standard Rating		
		80db/67wb	85	9.3 EER
		Integrated Part-Load Value		
		75 F Entering Water		8.3 IPLV
	≥65,000 <135,000 Btu/h Cooling Capacity	Standard Rating		
		80db/67wb	85	10.5 EER

Table 8.3-4a
Standard Rating Conditions and Minimum Performance
Packaged Terminal Air Conditioners and Heat Pumps
Air-Cooled, Electrically-Operated

Reference Standards	Category	Subcategory & Rating Condition (Outdoor Temps. °F)	Minimum Performance
ARI 310-87	PTAC's & PTAC H.P.'s[2] Cooling Mode	Standard Rating (95 db)	10.0-(.16 x Cap. (Btu/h)/1000) EER
		Low Temp. Rating (82 db)[1]	12.2-(.20 x Cap. (Btu/h)/1000) EER
ARI 380-87	PTAC H.P.'s - Heating Mode	Standard Rating (47db/43wb)	2.7 COP

1. For multi-capacity equipment the minimum performance shall apply to each capacity step provided and allowed by the controls.
2. If the unit's capacity is less than 7000 Btu/h, use 7000 Btu/h in the calculation. If the unit's capacity is greater than 15000 Btu/h, use 15000 Btu/h in the calculation.

Table 8.3-4b
Standard Rating Conditions & Minimum Performance
Room Air Conditioners and Room Air Conditioner Heat Pumps

Reference ANSI/AHAM RAC-1-82	Category	Minimum Performance[1]
	Without Reverse Cycle and With Louvered Sides	
	< 6000 Btu/h	8.0 EER
	≥ 6000 < 8000 Btu/h	8.5 EER
	≥ 8000 < 14000 Btu/h	9.0 EER
	≥ 14000 < 20000 Btu/h	8.8 EER
	≥ 20000 Btu/h	8.2 EER
	Without Reverse Cycle and Without Louvered Sides	
	< 6000 Btu/h	8.0 EER
	≥ 6000 < 20000 Btu/h	8.5 EER
	≥ 20000 Btu/h	8.0 EER
	With Reverse Cycle and With Louvered Sides	8.5 EER
	With Reverse Cycle, Without Louvered Sides	8.0 EER

1. To be consistent with National Appliance Energy Conservation Act of 1987 (Pub. L. 100-12).

Table 8.3-5
Standard Rating Conditions and Minimum Performance
Water-Source and Groundwater-Source Heat Pumps - Electrically-Operated
<135000 Btu/h Cooling Capacity

Reference Standards	Rating Condition °F[1]	Minimum Performance
Water-Source Heat Pumps ARI 320-86 CTI 201 (86)	Standard Rating 70 F Entering Water[2]	3.8 COP
Groundwater-Source Heat Pumps ARI 325-85	1. High Temperature Rating 70 F Entering Water[2]	3.4 COP
	2. Low Temperature Rating 50 F Entering Water[2]	3.0 COP

1. Air entering indoor section 70db/60wb (max.).
2. Water Flow Rate Per Manufacturer's Specifications.

Table 8.3-6
Standard Rating Conditions and Minimum Performance
Large Unitary Air Conditioners and Heat Pumps - Electrically-Operated
≥ 135,000 BTU/H Cooling Capacity

Category/ Reference Standards	Efficiency Rating	Minimum Performance	
Air Conditioners	EER	≤ 760,000 Btu/h	> 760,000 Btu/h
Air-Cooled ARI 360-65	IPLV	7.5	
Air Conditioners	EER	9.6	
Water/Evap.-Cooled ARI 360-85, CTI 201 (86)	IPLV	9.0	
Heat Pumps -Air-Cooled - Cooling	EER	≤ 760,000 Btu/h	> 760,000 Btu/h
	IPLV	7.5	
-Air-Cooled - Heating	COP (47 °F)	2.9	
ARI 340-86	COP (17 °F)	2.0	
Condensing Units	EER	9.9	
Air Cooled ARI 365-87	IPLV	11.0	
Condensing Units	EER	12.9	
Water/Evap.-Cooled ARI 365-87, CTI 201 (86)	IPLV	12.9	

1. For units that have a heating section, deduct 0.2 from all required EER's and IPLV's.
2. Condensing unit requirements are based on single-number ratings defined in paragraph 5.1.3.2 of ARI Standard 365-87.

Table 8.3-7
Standard Rating Conditions and Minimum Performance
Water-Chilling Packages - Water- and Air-Cooled - Electrically-Operated

Reference Standards	Category	Efficiency Rating	Minimum Performance
ARI 550-86 & ARI 590-86 CTI 201 (86)	Water - Cooled		
	≥ 300 tons	COP	5.2[1]
		IPLV	5.3[1]
	≥ 150 Tons < 300 tons	COP	4.2
		IPLV	4.5
	< 150 tons	COP	3.8
		IPLV	3.9
	Air-Cooled With Condenser		
	≥ 150 tons	COP	2.5
		IPLV	2.5
	< 150 tons	COP	2.7
		IPLV	2.8
	Condenserless, Air-Cooled		
	All Capacities	COP	3.1
		IPLV	3.2

1. Where R-22 or CFC refrigerants with equivalent ozone depletion factors are used these requirements are reduced to 4.7 COP and 4.8 IPLV (see Section 8.3.1.1)

NOTE: The levels above are minimum performance levels. Better energy efficiencies may be available, and their use is encouraged.

Table 8.3-8
Standard Rating Conditions and Minimum Performance
Boilers: Gas- and Oil-Fired

Reference	Category	Rating Condition	Minimum Performance
DOE Test Procedure 10 CFR, Part, 30 App N	Gas-Fired <300,000 Btu/h	Seasonal Rating	AFUE 80%[1,3]
	Oil-Fired <300,000 Btu/h	Seasonal Rating	AFUE 80%[1]
AGA Z21.13-82 H.I. Htg. Boiler Std. 86 ASME PTC4.1-64 U.L. 795-73	Gas-Fired ≤300,000 Btu/h	1. Max. Rated Cap.[2] Steady-State	E_c[4] 80%
		2. Min. Rated Cap.[2] Steady-State	E_c[4] 80%
U.L. 726-75 H.I. Htg. Boiler Std. 86 ASME PTC 4.1-64	Oil-Fired ≥300,000 Btu/h	1. Max. Rated Cap.[2] Steady-State	E_c[4] 83%
		2. Min. Rated Cap.[2] Steady-State	E_c[4] 83%
H.I. Htg. Boiler Std. 86 ASME PTC 4.1-64	Oil-Fired (Residual) ≥300,000 Btu/h	1. Max. Rated Cap.[2] Steady-State	E_c[4] 83%
		2. Min. Rated Cap.[2] Steady-State	E_c[4] 83%

1. To be consistent with National Appliance Energy Conservation Act of 1987 (Pub. L. 100-12).
2. Provided and allowed by the controls.
3. Except for gas-fired steam boilers for which minimum AFUE is 75%.
4. E_c = combustion efficiency, 100% - flue losses.

Table 8.3-9
Standard Rating Conditions and Minimum Performance
Warm-Air Furnaces and Combination Warm-Air Furnaces/Air-Conditioning Units

Reference	Category	Rating Condition	Minimum Performance
DOE Test Procedure 10 CFR, Part 30 App. N	Gas-Fired <225,000 Btu/h	Seasonal Rating	AFUE 78%[1,3]
	Oil-Fired <225,000 Btu/h	Seasonal Rating	AFUE 78%[1]
AGA Z21.47-83	Gas-Fired ≥225,000 Btu/h	1. Max. Rated Cap.[2] Steady-State	E_t[4] 80%
		2. Min. Rated Cap.[2] Steady-State	E_t[4] 78%
U.L. 727-86	Oil-Fired ≥225,000 Btu/h	1. Max. Rated Cap.[2] Steady-State	E_t[4] 81%
		2. Min. Rated Cap.[2] Steady-State	E_t[4] 81%

1. To be consistent with National Appliance Energy Conservation Act of 1987 (Pub. L. 100-12).
2. Provided and allowed by the controls.
3. Minimum performance requirements for furnaces <45,000 Btu/h capacity are to be established by DOE under Pub. L. 100-12.
4. E_t = thermal efficiency, 100% - flue losses.

Table 8.3-10
Warm Air Duct Furnaces and Unit Heaters

Reference	Category	Rating Conditions	Minimum Performance
AGA Z83.9-86	Duct Furnaces Gas-Fired	1. Max. Rated Cap.[1] Steady-State	E_t[2] 78%
		2. Min. Rated Cap.[1] Steady-State	E_t[2] 75%
AGA Z83.8-85	Unit Heaters Gas-Fired	1. Max. Rated Cap.[1] Steady-State	E_t[2] 78%
		2. Min. Rated Cap.[1] Steady-State	E_t[2] 75%
U.L 731-75	Unit Heaters Oil-Fired	1. Max. Rated Cap.[1] Steady-State	E_t[2] 81%
		2. Min. Rated Cap.[1] Steady-State	E_t[2] 78%

1. Provided and allowed by the controls.
2. E_t = thermal efficiency, 100% -flue losses.

§ 435.109 Service water heating systems.

9.1 General

9.1.1 This section contains minimum and prescriptive requirements for the design of Service Water Heating Systems.

9.1.2 A building shall be considered in compliance with this section if the following conditions are met:

9.1.2.1 The minimum requirements of section 9.3 are met; and

9.1.2.2 The Service Water Heating System design complies with the prescriptive criteria of section 9.4.

9.2 Principles of Design

9.2.1 Showerheads shall be designed to provide and maintain user comfort and energy savings. They should not use removable flow restricting inserts to meet flow limitation requirements.

9.2.2 Point of use water heaters shall be considered where their use will reduce energy consumption and is life cycle cost effective.

9.2.3 High temperature condensate, when returned to condensation pump tanks or other vented tanks, will have a certain portion flashed into steam, thus wasting energy. To conserve this energy, a heat exchanger shall be considered for use in the condensate return line to heat or preheat the service water, cool the condensate, and prevent flashing.

9.2.4 Storage may be used to optimize heat recovery when the flow of heat to be recovered is out of phase with the demand for heated water, or when energy use for water heating can be shifted to take advantage of off-peak rates.

9.3 Minimum Requirements

9.3.1 Sizing of Systems

9.3.1.1 Service water heating system design loads for the purpose of sizing and selecting systems shall be determined in accordance with the procedures described in chapter 54 of the *ASHRAE Handbook, 1987 HVAC Systems and Applications Volume,* or a similar computation procedure.

9.3.2 Equipment Efficiency

9.3.2.1 All water heaters and hot water storage tanks shall meet the criteria of Table 9.3–1. Where multiple criteria are listed, all criteria shall be met. Where no criteria are provided, no requirements need be met.

TABLE 9.3–1.—STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE OF WATER HEATING EQUIPMENT

[January 30, 1989]

Type	Fuel	Storage capacity (gal)	Input rating	Applicable test procedure	Minimum performance	
					DOE rating	Eff.
Storage water heaters	Electric	<120	<12 kW	DOE Test Procedures, 1985 Code of Federal Regulations Title 10, Part 430.	EF gt;0.95–0.00132V.	
		gt;120 (or)	gt;12 kW	ANSI C72.1—1972		
	Gas	<100	<75,000 Btu/h	DOE Test Procedures, 1985 Code of Federal Regulations Title 10, Part 30.	EF gt;0.62–0.0019V	
		gt;100 (or)	gt;75,000 Btu/h	ANSI Z21.10.3–198 Gas Water Heaters w/Addenda Z21.10.3a—1985.		E_t 77%
	Oil	<50.	<75,000 Btu/h	DOE Test Procedures, 1985 Code of Federal Regulations Title 10, Part 430.	EF gt;0.59–0.0019V	
			<105,000 Btu/h		gt;0.59–0.0019V	
		gt;50 (or)	gt;105,000 Btu/h			E_c 83%

TABLE 9.3–1.—STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE OF WATER HEATING EQUIPMENT (CONT.)

[January 30, 1989]

		Type		Applicable test procedure	Minimum performance	
Class	Fuel	Capacity	Input rating			
Unfired Storage	1	All Volume	All Inputs		HL. <6.5 Btu/ h ft².	
Instantaneous	Gas		All Inputs	ANSI Z21.10.3—1984	E_t 80%	
	Distill Oil		All Inputs		E_c 83%	
Pool Heaters	Gas/Oil		All Inputs	ANSI Z21.56—1986	E_t 78%[c]	

Notes for Table 9.3–1:

Terms Defined:

1. EF = Energy factor, overall heater efficiency by DOE Test Procedure E_t = Thermal efficiency with 70°F, eT E_c = Combustion efficiency, 100 percent—flue loss when smoke = 0 (trace is permitted) HL = Heat loss of tank surface area V = Storage volume in gallons

9.3.2.1.1 *Exception to section 9.3.2.1*

(a) storage water heaters and hot water storage tanks having more than 500 gallons of storage capacity need not meet the heat loss (HL) requirements of Table 9.3–1 if the tank surface area is thermally insulated to R–12.5 and if a standing pilot light is not used.

9.3.2.2 *Heat Traps.* Storage water heaters not equipped with integral heat traps and having vertical pipe risers shall be installed with heat traps on both the inlet and outlets. The heat trap shall be installed directly, or as close as possible to the outlet fittings. Circulating systems need not employ heat traps.

9.3.2.2.1 A heat trap may take the form of a bent piece of tubing that forms a loop of 360 degrees; an arrangement of pipe fittings, such as elbows, connected so that the inlet and outlet piping make vertically upward runs just before turning downward to connect to the water heater's inlet and outlet fittings; a commercially available heat trap; or any other type that effectively restricts the natural tendency of hot water to rise in the vertical pipe during standby periods.

9.3.2.2.2 When the water heater outlet is directly horizontal out of the tank, or is piped with an elbow on the vertical outlet and then downward, this piping arrangement itself is effectively a heat trap and a separate heat trap is not then needed.

9.3.3 Piping Insulation

9.3.3.1 For circulating systems, piping insulation shall conform to the requirements of Table 7.3–1 or an equivalent level as calculated in accordance with Equation 7.3–1.

9.3.3.2 For non-circulating systems, the first 8 ft of piping from a storage system that is maintained at a constant temperature shall be insulated in accordance with Table 7.3–1, or an equivalent level as calculated in accordance with Equation 7.3–1. Systems without a heat trap to prevent circulation due to natural convection shall be considered circulating systems.

9.3.4 Controls

9.3.4.1 *Temperature.* Service water heating systems shall be equipped with temperature controls capable of adjustment from 90 °F to a temperature setting compatible with intended use, except for systems serving residential dwelling units may be equipped with controls capable of adjustment down to 110 °F only. (See *ASHRAE Handbook, 1987 Systems and Applications Volume,* Chapter 54, Table 3).

9.3.4.1.1 Where temperatures higher than 120 °F are required at certain outlets for a particular intended use, separate remote heaters or booster heaters shall be installed for those outlets unless it can be shown by calculation that either energy is not saved by the application of this requirement or that the total cost over the life of the equipment is not reduced.

9.3.4.1.2 *Circulating Hot Water Systems and Heated Pipes.* Systems designed to maintain temperatures in hot water pipes, including circulating hot water systems and heat tape on water pipes, shall be equipped with automatic controls that can be set to turn off the system when hot water is not required.

9.3.5 Equipment and Control Requirements for the Conservation of Hot Water

9.3.5.1 Showers used for other than safety reasons shall limit the maximum hot water discharge to 2.75 gpm when tested according to *ANSI A112.18.1M–1979,* ''Finished and Rough Brass Plumbing Fixtures''. The designer shall evaluate the use of lower flow showerheads than 2.75 gpm, particularly for heavily used facilities. Removable flow restricting inserts shall not be used in showerheads to meet this criterion. When flow restricting inserts are used as a component part of a showerhead, they shall be mechanically retained at the point of manufacture. [Mechanically retained means a pushing or pulling force to remove the flow restricting insert at 8 pounds or more.] This requirement shall not apply to showerheads that will cause water to leak significantly from areas other than the spray face, if the flow restricting insert were removed.

9.3.5.2 Lavatories in public restrooms, with the exception of lavatories for physically handicapped persons, shall be equipped with devices that:

9.3.5.2.1 Limit the flow of hot water to either:

(a) A maximum of 0.5 gpm;

(b) 0.75 gpm if a device or fitting is used that limits the period of water discharge, such as a foot switch, fixture occupancy sensor; or

(c) 2.5 gpm if equipped with a self-closing valve;

9.3.5.2.2 Either be equipped with a foot switch or occupancy sensor or similar device or limit delivery with a self-closing valve or a foot switch to a maximum of 0.25 gallons of hot water for circulating systems;

9.3.5.2.3 Limits delivery with a self-closing valve or a foot switch to a maximum of 0.50 gallons for non-circulating systems; and

9.3.5.2.4 Limits the outlet temperature to a maximum 110 °F.

9.3.6 Swimming Pools

9.3.6.1 *Pool Heaters.* All pool heaters shall meet the criteria of Table 9.3–1 and be equipped with a readily accessible ''on-off'' switch to allow system shut-off without adjusting the thermostat setting and, when applicable, allow restarting without manually re-lighting the pilot light.

9.3.6.2 *Pool Covers.* Outdoor heated swimming pools shall be equipped with a pool cover. However, pools deriving over 70% of the energy for heating from non-depletable sources or from recovery of energy that would otherwise be wasted (computed over an operating season) need not be equipped with pool covers.

9.3.6.3 *Time Switches.* Time switches shall be installed on all swimming pool pumps and all electric swimming pool heaters. These switches shall allow for the shutdown of heaters during hours of peak utility demand except as is necessary in peak period operation to maintain water in a clear and sanitary condition in keeping with applicable public health standards.

9.3.6.3.1 *Exceptions to section 9.3.5.3:*

(a) Where public health standards require 24 hour operation of pumps; and

(b) Pumps are required to operate solar pool heating systems.

9.4 Service Hot Water Heating Systems—Prescriptive Compliance Alternative

9.4.1 Combination Service Water Heating/Space Heating Equipment

9.4.1.1 Water heaters used for combination service water and space heating shall meet the appropriate minimum efficiency requirements of both section 8.3 and 9.3.

9.4.1.2 Combination space heating and service water heating equipment shall only be used when at least one of the following conditions is met:

9.4.1.2.1 where the annual space heating energy use is less than 50% of the annual service water heating energy use;

9.4.1.2.2 where the energy input or storage volume of the combined boiler or water heater is less than twice the size of the smaller of the separate boilers or water heaters otherwise required;

9.4.1.2.3 where calculations show that the combined system uses no more energy than separate systems that meet the requirements of sections 8.3 and 9.3; or

9.4.1.2.4 where the input to the combined boiler is less than 150,000 Btu/h.

9.4.1.3 Combination function equipment (space heating, service water heating, cooling, etc.) shall comply with minimum efficiency requirements in accordance with nationally recognized test procedures. Where such procedures are not available for particular equipment designs, compliance shall be determined based on the function representing the maximum annual energy consumption, using data provided by equipment and component manufacturers.

9.4.2 Additional Equipment Efficiency Measures

9.4.2.1 *Electric Water Heaters.* In applications where water temperatures not greater than 145 °F are required, an economic evaluation shall be made on the potential benefit of using an electric heat pump water heater(s) instead of electric resistance water heater(s). The analysis shall compare the extra costs of the heat pump unit with the benefits in reduced energy costs, less increased maintenance costs, over the estimated service life of the heat pump water heater.

9.4.2.1.1 *Exception to section 9.4.2.1:*

(a) Electric resistance water heaters used in conjunction with site-recovered or non-depletable energy sources or off-peak heating with thermal storage.

9.4.2.2 *Gas-Fired Water Heaters.* All gas-fired storage water heaters that use indoor air for combustion or draft hood dilution and that are installed in a conditioned room shall be equipped with a vent damper unless the water heater is already so equipped. Unless the water heater has an available electrical supply, the installation of such a vent damper shall not require an electrical connection. The vent damper shall be listed as meeting appropriate ANSI standards and shall be installed in accordance with manufacturer's instructions and local codes.

9.4.2.2.1 *Exception to section 9.4.2.2:*

(a) where the cost of the damper exceeds the value of reduced energy costs over the damper's lifetime.

9.4.3 Use of Waste Heat, Solar Energy, and Thermal Storage

9.4.3.1 An evaluation shall be made of the potential for the use of condenser heat, waste energy, solar energy, or off-peak heating with thermal storage to reduce water heating energy cost.

9.4.3.2 Storage shall be used to optimize heat recovery when the flow of heat to be recovered is out of phase with the demand for heated water, or when energy use for water heating can be shifted to take advantage of off-peak rates.

[54 FR 4554, Jan. 30, 1989, as amended at 55 FR 23869, June 12, 1990; 59 FR 18294, Apr. 18, 1994]

§435.110 Energy management.

10.1 General

10.1.1 This section contains minimum requirements for building energy management systems. It describes the energy measurement, control, testing and documentation that shall be provided to the building owner. The intent is to minimize energy use by providing the building operator with design, construction and equipment data, along with a means of testing the completed facility.

10.1.2 A building shall be considered in compliance with this section if the minimum requirements of Section 10.3 are met.

10.2 Principles of Design

10.2.1 Energy Management Control Systems

10.2.1.1 An energy management control system is critical to the effective management of building energy. Energy management systems require measurements at key points in the building system and must be capable of part-load operation recognition and be equipped with controls to match system capacity to load demands.

10.2.1.2 Controls cannot correct inadequate source equipment, poorly selected components, or mismatched systems. Energy efficiency requires a design that is optimized by realistic loads prediction, careful system selection, and full control provisions.

10.2.2 Building Operating Documentation

10.2.2.1 The building construction drawings and specifications must show system types, sizes, performance criteria, controls, and materials intended for use prior to construction. The system designer shall provide or specify that documentation be provided for the education and guidance of the building operator showing the actual elements that have been installed, how they have been installed, how they performed during testing, and how they operate as a system in the completed facility. Since minimum energy use is the ultimate goal, operating procedures are one of the major factors in controlling energy use in buildings. The activities of building occupants and operators can result in differences as great as two to one in the energy consumption of essentially similar buildings. While neither the designer nor these standards can control the way the building is actually operated, the designer shall contribute to the education and guidance of the building operator by including this documentation in the contract specifications.

10.2.2.2 The building operator shall be provided with the following:

10.2.2.2.1 As-built drawings and specifications;

10.2.2.2.2 Operating manuals with a schematic diagram, sequence of operation and system operating criteria for each and all systems installed;

10.2.2.2.3 Where the building systems are complex, a comprehensive balancing and testing program and report to demonstrate the energy performance capabilities of the system; and

10.2.2.2.4 Maintenance manuals with complete information for all major components in the facility.

10.3 Minimum Requirements

10.3.1 Each distinct utility-provided energy service shall be metered. This shall apply to central and individual tenant meters. Such meters shall be located, or arranged, so that the meter can be visually monitored.

10.3.2 Each distinct commercially-provided energy service shall have a system to measure and record the amount of energy being delivered, based on the energy content.

10.3.3 The energy delivery systems shall be arranged to allow individual measurement of occupant lighting and outlet services, production processes, auxiliary systems, service water heating, space heating, space cooling, and HVAC delivery systems.

10.3.4 Provisions shall be made for the measurement of energy inputs and outputs (flow, temperature, pressure, etc.) to determine equipment energy consumption and/or installed performance capabilities and efficiencies of all heating, cooling, and HVAC delivery systems equipment, greater than 20 kVA or 60,000 Btu/h energy input.

10.3.5 Energy Measurement Instrumentation

10.3.5.1 In buildings or tenant areas with electric service greater than 150 kVA or fuel use greater than 500,000 Btu/h, energy use shall be measured for electrical lighting, miscellaneous power outlets, HVAC systems and equipment, service hot water, and process loads and when the peak use of:

10.3.5.1.1 Production processes, including manufacturing, computers, laundries, kitchens, etc., is greater than 100 kVA or 300,000 Btu/h;

10.3.5.1.2 Auxiliary systems and service water heating is greater than 100 kVA or 300,000 Btu/h;

10.3.5.1.3 Space heating (including reheat) is greater than 100 kVA or 300,000 Btu/h;

10.3.5.1.4 Space cooling is greater than 100 kVA or 300,000 Btu/h; and

10.3.5.1.5 HVAC delivery systems is greater than 100 kVA or 300,000 Btu/h.

10.3.5.1.6 *Exception to section 10.3.5.1:*

(a) When there is an energy service for only 2 of the 6 categories listed, a single measurement may be made for the larger of the two energy services and the second use determined by subtraction from the primary service measurements.

10.3.6 HVAC System Controls

10.3.6.1 The designer shall designate, specify, or otherwise show in the construction documents the type of controls and control systems needed. This shall include a description or sequence of control of the system's operational procedures.

10.3.6.2 Controls may be electric, pneumatic, electronic, or direct digital. Control action may be ''on/off'', or proportional that can use manual, automatic, or remote reset and can have rate of action or derivative action compensation as designated by the designer. Control devices may be provided by the manufacturers of equipment or by the field installers, but all shall be compatible with the design sequence of control. The designer shall designate accuracy and long term requirements for controls.

10.3.6.3 All primary energy conversion equipment such as boilers, heat exchangers, refrigeration units, furnaces and heat pumps shall have a load activated local control loop for each piece of equipment. Controls for multiple equipment shall integrate the individual control units or provide system control for all the units.

10.3.6.4 All energy delivery systems shall have a local control loop for each system.

10.3.6.5 Energy consuming systems or components with a peak use greater than 1 kW or 3,500 Btu/h shall be provided with a means of shut-off when occupancy or weather conditions do not require its operation.

10.3.6.6 The control equipment provided for local control loops except for "on/off" and self-contained sensor devices shall be arranged so that sensing, control action, and control setting variables can be read or tested at the device.

10.3.6.7 Control loops for terminal unit zones with less than 24 hours per day or 7 days per week occupancy shall have separate control points for day and night heating and cooling. The devices shall be capable of local resetting, and have provisions for remote management system selection of the occupied or unoccupied heating or cooling mode of operation.

10.3.7 Central Monitoring and Control Systems

10.3.7.1 A central monitoring and control system shall be provided in any building or submetered tenant space exceeding 40,000 ft^2 in gross floor area.

10.3.7.2 The minimum energy management requirements for such a system shall be to:

10.3.7.2.1 Read and retain daily totals for all energy measurement instruments;

10.3.7.2.2 Total all energy values weekly and record and retain values placed on a summary report;

10.3.7.2.3 Record and plot hourly outdoor and indoor temperatures against real time and summarize and report for each year in a format compatible with degree-days or bin temperature;

10.3.7.2.4 Based on time schedules, turn on or off any HVAC or service water heating system or equipment;

10.3.7.2.5 Based on time schedules, turn on or off major building lighting and occupancy power circuits;

10.3.7.2.6 Reset local loop control systems for HVAC equipment;

10.3.7.2.7 Monitor and verify operation of heating, cooling and energy delivery systems;

10.3.7.2.8 Monitor and verify operation of lighting and occupant power, auxiliary and service hot water systems;

10.3.7.2.9 Provide readily accessible override controls so that time-based HVAC and lighting controls may be temporarily overridden during off hours; and

10.3.7.2.10 Provide optimum start/stop for HVAC systems.

10.3.8 Completion Requirements

10.3.8.1 The building construction documents shall describe the requirements for placing all energy management systems in operation. This includes check-out procedures and all controls and metering equipment operational information.

10.3.8.2 The building construction documents shall describe the requirements for balancing and check-out procedures for all HVAC systems and equipment. All HVAC system balancing shall be required to be accomplished in a manner to minimize throttling losses. In air systems, fan speeds shall be required to be adjusted to meet design conditions. Water systems shall be required to be proportionally adjusted to minimize throttling losses and then corrected to design flow conditions by trimming the pump impeller or changing pump speed. The design specifications shall state that a pump shall not be brought to final flow conditions by valving.

10.3.8.3 The building construction documents shall describe the requirements for control system testing to assure that control elements are calibrated, ranges adjusted, set points ascertained, and full travel of moveable elements assured. All elements in the control system shall be tested with the system in operation.

10.3.9 Energy Performance Testing

10.3.9.1 The building construction documents shall describe the requirements for determining building energy performance in the completed, operational building.

10.3.9.2 The building energy performance testing shall be performed in winter for heating and in summer for cooling. These tests shall ascertain the in-site capabilities of all HVAC systems and equipment. Internal building loads shall be accounted for in assessing cooling performance. Heating performance shall be determined during unoccupied night time periods during winter weather. If any internal load, such as lighting, contributes to building heating, such loads shall be accounted for in assessing heating performance.

10.3.9.3 Energy use measurements shall be made for the overall building system while HVAC system performance is being tested. Each energy management and control system shall be used to determine energy use for:

10.3.9.3.1 Utility energy;

10.3.9.3.2 Commercial service energy:

10.3.9.3.3 Occupant lighting and receptacle power;

10.3.9.3.4 Production process energy;

10.3.9.3.5 Auxiliary systems and service water heating energy;

10.3.9.3.6 Space heating energy;

10.3.9.3.7 Space cooling energy; and

10.3.9.3.8 HVAC delivery system energy.

10.3.9.3.9 Test periods shall be at least six (6) hours in duration. Hourly outdoor and indoor temperatures, solar intensity during a day test, and wind speed during a night test shall be recorded.

10.3.9.4 The building energy performance test data shall, at minimum, measure energy use and outdoor temperatures hourly for each test period.

10.3.10 Documentation Data Requirements

10.3.10.1 As-built information shall be provided for all the following energy-related features of the building:

10.3.10.1.1 Thermal and solar/optical transmission characteristics of the building envelope, including infiltration;

10.3.10.1.2 The operating characteristics of the HVAC, lighting, and service water heating equipment and systems;

10.3.10.1.3 Internal heat gain contributed by equipment and processes; and

10.3.10.1.4 The operating characteristics of controls.

10.3.10.2 A summary report shall be provided outlining the design basis data for the building envelope, the internal heat gains, the weather extremes, major heating/cooling equipment sizes and sequence of operation.

10.3.10.3 The construction documents shall require that shop drawings, schematic diagrams, control sequence, maintenance manuals, and operating instructions, with data on all HVAC, auxiliary equipment and service water heating systems be provided to the owner.

10.3.10.4 A system balancing report shall be provided that follows National Environmental Balancing Bureau or the Association of Air Balancing Council formats with an extra section summarizing the energy-related values gathered during balancing.

10.3.10.5 An energy performance test report shall be provided showing all the data gathered during the energy performance tests. The results shall be presented in a format that provides convenient comparison with design values.

§435.111 Building energy cost compliance alternative.

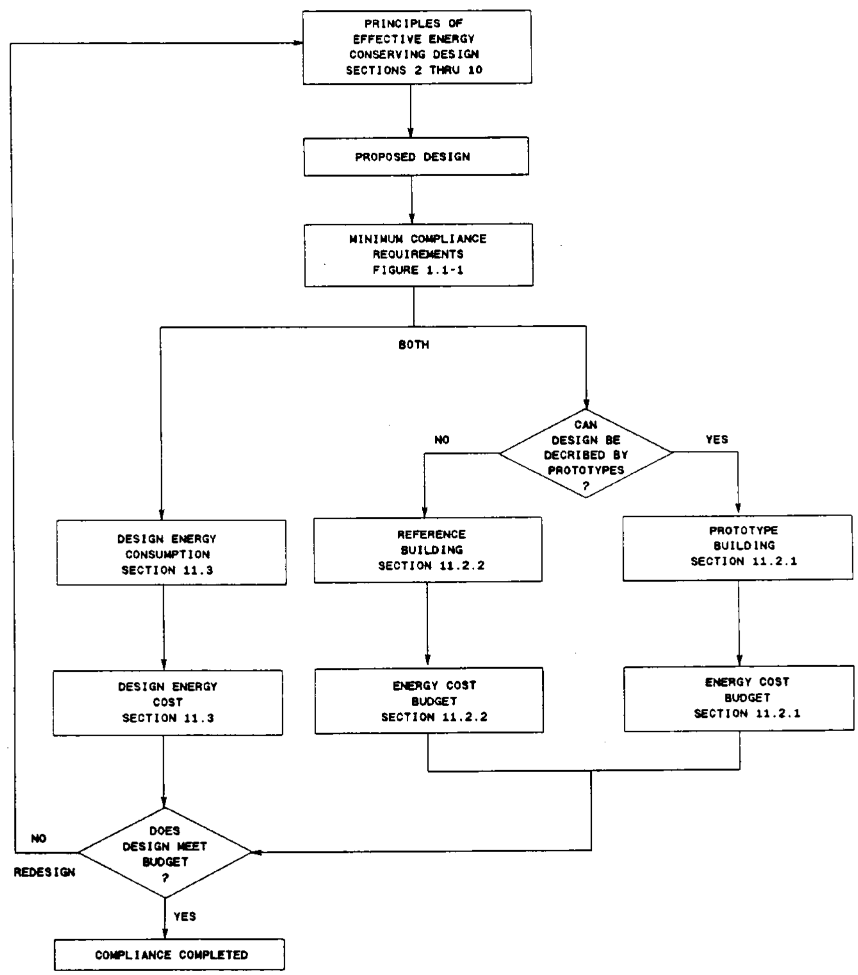
11.1 General

11.1.1 This section provides an alternative compliance path that allows greater flexibility in the design of energy efficient buildings using an annual energy cost method. Energy cost is used as the common denominator in determining compliance. Using unit costs rather than units of energy or power such as Btu, kWh or kW allows the energy use contribution of different fuel sources at different times to be added and compared. This path allows for innovation in designs, materials, and equipment, such as daylighting, passive solar heating, heat recovery, better zonal temperature control, thermal storage, and other applications of off-peak electrical energy, that cannot be adequately evaluated by the prescriptive or system performance alternatives found in sections 3.4, 3.5, 5.4, 5.5, and 7.4. This compliance path is intended for design comparisons only and is not intended to be used to either predict, document, or verify annual energy consumption or annual energy costs.

11.1.2 The Building Energy Cost Compliance Alternative is to be used in lieu of the prescriptive or system performance methods and in conjunction with the minimum requirements found in sections 3.3, 4.3, 5.3, 6.3, 7.3, 8.3, 9.3 and 10.3.

11.1.3 *Compliance.* Compliance under this method requires detailed energy analyses of the entire Proposed Design, referred to as the Design Energy Consumption; an estimate of annual energy cost for the proposed design, referred to as the Design Energy Cost; and comparison against an Energy Cost Budget. Compliance is achieved when the estimated Design Energy Cost is less than or equal to the Energy Cost Budget (see Figure 11–1). This section provides instructions for determining the Energy Cost Budget and for calculating the Design Energy Consumption and Design Energy Cost. The Energy Cost Budget shall be determined through the calculation of monthly energy consumption and energy cost of a Prototype or Reference Building design configured to meet the requirements of sections 3.0 through 10.0.

Figure 11-1 Building Energy Cost Compliance Alternative



11.1.4 Designers are encouraged to employ the Building Energy Cost Budget compliance method set forth in this section for evaluating proposed design alternatives in preference to using the prescriptive/system methods. The Building Energy Cost Budget establishes the relative effectiveness of each design alternative in energy cost savings, providing an energy cost basis upon which the building owner and designer may select one design over another. This Energy Cost Budget is the highest allowable calculated Energy Cost Budget for a specific building design. Other alternative designs are likely to have lower annual energy costs and life cycle costs than those that minimally meet the Energy Cost Budget.

11.1.5 The Energy Cost Budget is a numerical target for annual energy cost. It is intended to assure neutrality with respect to choices of HVAC system type, architectural design, fuel choice, etc., by providing a fixed, repeatable budget target that is independent of any of these choices wherever possible (i.e., for the prototype buildings). The Energy Cost Budget for a given building size and type will vary only with climate, the number of stories, and the choice of simulation tool. The specifications of the prototypes are necessary to assure repeatability, but have no other significance. They are not recommended energy conserving practice, or even physically reasonable practice for some climates or buildings, but represent a reasonable worst case of energy cost resulting from compliance with the spirit and the letter of sections 3.0 through 10.0.

11.2 Determination of the Annual Energy Cost Budget

11.2.1 The annual Energy Cost Budgets shall be determined in accordance with the Prototype Building Method in section 11.2.5, or the Reference Building Method in section 11.2.5. Both methods calculate an annual Energy Cost by summing the 12 monthly Energy Cost Budgets. Each monthly Energy Cost Budget is the product of the monthly Building Energy Consumption of each type of energy used multiplied by the monthly Energy Cost per unit of energy for each type of energy used.

11.2.2 The Energy Cost Budget shall be determined in accordance with Equation 11–1 as follows:

$$ECB = ECB_{jan} + \ldots ECB_{m} + \ldots + ECB_{dec}$$

Equation 11–1

Based on:

$$ECB_{m} = BECON_{m1} \times ECOS_{m1} + \ldots + BECON_{mi} \times ECOS_{mi}$$

Equation 11–2

Where:

ECB=The annual Energy Cost Budget
ECB_m=The monthly Energy Cost Budget
$BECON_{mi}$=The monthly Budget Energy Consumption of the i^{th} type of energy
$ECOS_{mi}$=The monthly Energy Cost, per unit of the i^{th} type of energy

11.2.3 The monthly Energy Cost Budget shall be determined using current rate schedules or contract prices available at the building site for all non-depletable types of energy purchased. These costs shall include demand charges, rate blocks, time of use rates, interruptable service rates, delivery charges, taxes, and all other applicable rates for the type, location, operation, and size of the proposed design. The monthly Budget Energy Consumption shall be calculated from the first day through the last day of each month, inclusive.

11.2.4 The Energy Cost Budget, Design Energy Consumption and Design Energy Cost calculations are applicable only for determining compliance with these standards. They are not predictions of actual energy consumption or costs of the proposed building after construction. Actual experience will differ from these calculations due to variations such as occupancy, building operation and maintenance, weather, energy use not covered by these standards, changes in energy rates between design of the building and occupancy, and precision of the calculation tool.

11.2.5 Prototype Building Procedure

11.2.5.1 The Prototype Building procedure shall be used for all building types listed below. For mixed-use buildings the Energy Cost Budget is derived by allocating the floor space of each building type within the floor space of the prototype building. For buildings not listed below, the Reference Building procedure of section 11.2.5 shall be used.

11.2.5.1.1 Prototype buildings include:

(a) Assembly;
(b) Office (Business);
(c) Retail (Mercantile);
(d) Warehouse (Storage);
(e) School (Educational);
(f) Hotel/Motel;
(g) Restaurant;
(h) Health/Institutional; and
(i) Multi-Family.

11.2.5.2 Use of the Prototype Building to Determine the Energy Cost Budget

11.2.5.2.1 Determine the building type of the Proposed Design using the categories in section 11.2.5.1. Using the appropriate Prototype Building characteristics from Tables 11–1 through 11–8, the building shall be simulated using the same gross floor area and number of floors for the Prototype Building as in the Proposed Design.

11.2.5.2.3 The form, orientation, occupancy and use profiles for the Prototype Building shall be fixed as described in section 11.5.3. Envelope, lighting, other internal loads and HVAC systems and equipment shall meet the prescriptive or system requirements of section 3.0 through 10.0 and are standardized inputs.

11.2.6 Reference Building Method

11.2.6.1 The Reference Building procedure shall be used only when the Proposed Design cannot be represented by one or a combination of the Prototype Building listed in section 11.2.5.1 or the assumptions for the Prototype Building in section 11.5, such as occupancy and use-profiles, do not reasonably represent the Proposed Design.

11.2.6.2 Use of the Reference Building to Determine the Energy Cost Budget

11.2.6.2.1 Each floor shall be oriented in the same manner for the Reference Building as in the Proposed Design. The form, gross and conditioned floor areas of each floor and the number of floors shall be the same as in the Proposed Design. All other characteristics, such as lighting, envelope and HVAC systems and equipment, shall meet the prescriptive/system requirements of section 3.0 through 10.0.

11.2.7 Calculation Procedure and Simulation Tool

11.2.7.1 The Prototype or Reference Buildings shall be modeled using the criteria of section 11.5 and section 11.6. The modeling shall use a climate data set appropriate for both the site and the complexity of the energy conserving features of the design. ASHRAE Weather Year for Energy Calculations (WYEC) data or bin weather data shall be a default choice.

11.3 Determination of the Design Energy Consumption and Design Energy Cost

11.3.1 The Design Energy Consumption shall be calculated by modeling the Proposed Design using the same methods, assumptions, climate data, and simulation tool as were used to establish the Energy Cost Budget, except as explicitly stated in 11.5. The Design Energy Cost shall be calculated per Equation 11–3. If the Proposed Design includes cogeneration or non-depletable energy sources designed for the sale of energy off-site, then energy cost and income resulting from outside sales shall not be used to reduce the Design Energy Costs. Such systems shall be modeled as operating to supply energy needs of the Proposed Design only.

$$DECOS=DECOS_{jan}+ \ldots DECOS_{m} \ldots . +DECOS_{dec}$$

Equation 11–3

Based on:

$$DECOS_{m}=DECON_{m1}\times ECOS_{m1}+ \ldots +DECON_{mi}\times ECOS_{mi}$$

Equation 11–4

Where:

$DECOS$=The annual Design Energy Cost

$DECOS_{m}$=The monthly Design Energy Cost

$ICON_{mi}$=The monthly Design Energy Consumption of the i^{th} type of energy

$ECOS_{mi}$=The monthly Energy Cost per unit of the i^{th} type of energy

The $DECON_{mi}$ shall be calculated from the first day through the last day of the month, inclusive.

11.4 Compliance

11.4.1 If the Design Energy Cost is less than or equal to the Energy Cost Budget, and all of the minimum requirements of sections 3.0 through 10.0 are met, the Proposed Design complies with the standards.

11.5 Standard Calculation Procedure

11.5.1 The Standard Calculation Procedure consists of methods and assumptions for calculating the Energy Cost Budget for the Prototype or Reference Building and the Design Energy Consumption and Design Energy Cost of the Proposed Design. In order to maintain consistency between the Energy Cost Budget and the Design Energy Cost, the input assumptions to be used are stated below. These inputs shall be used to determine the Energy Cost Budget and the Design Energy Consumption.

11.5.2 Prescribed assumptions shall be used without variation. Default assumptions shall be used unless the designer can demonstrate that a different assumption better characterizes the building's energy use over its expected life. No modified default assumptions shall be used in modeling both the Prototype or Reference Building and the Proposed Design unless the designer demonstrates clear cause to do otherwise. Special procedures for speculative buildings are discussed in section 11.5.9. Shell buildings may not use section 11.0.

11.5.3 Orientation and Shape

11.5.3.1 The Prototype Building shall consist of the same number of stories, and gross and conditioned floor area as the Proposed Design, with equal area per story. The building shape shall be rectangular, with a 2.5:1 aspect ratio. The long dimensions of the building shall face East and West. This is intended to provide an energy budget that can be met even if there are unfavorable site constraints. The fenestration shall be uniformly distributed in proportion to exterior wall area.

11.5.3.2 Floor-to-floor height for the Prototype Building shall be 13 ft except for dwelling units in hotels/motels and multi-family high rise residential buildings where floor-to-floor height shall be 9.5 ft.

11.5.3.3 The Reference Building shall consist of the same number of stories, and gross floor area for each story as the Proposed Design. Each floor shall be oriented in the same manner as the Proposed Design. The geometric form shall be the same as the Proposed Design.

11.5.4 Internal Loads

11.5.4.1 The systems and types of energy specified in this section are intended only as constraints in calculating the Energy Cost Budget. They are not intended as either requirements or recommendations for either systems or the type of energy to be used in the Proposed Design or for calculation of Design Energy Cost.

11.5.4.2 Internal loads for multi-family high rise residential buildings are presented in Table 11–1. These assumptions shall be prescribed assumptions. Internal loads for other building types shall be modeled as noted in this subsection.

11.5.4.2.1 Occupancy

(a) Occupancy schedules shall be Default Assumptions. The same assumptions shall be made in computing Design Energy Consumption as were used in calculating the Energy Cost Budget.

(b) Table 11–2, Occupancy Density, establishes the density, in ft^2/person of conditioned floor area, to be used for each building type. Table 11–3, Building Schedule Percentage Multipliers, establishes the percentage of total occupants in the building by hour of the day for each building type.

11.5.4.2.2 Lighting

(a) Interior Lighting Power Allowance (ILPA), for calculating the Energy Cost Budget shall be determined from section 3.0. The lighting power used to calculate the Design Energy Consumption shall be the actual adjusted power for lighting in the Proposed Design. If the lighting controls in the Proposed Design are more effective at saving energy than those required by section 3.3, the actual installed lighting power shall be used along with the schedules reflecting the action of the controls to calculate the Design Energy Consumption. This actual installed lighting power shall not be adjusted by the Power Adjustment Factors listed in Table 3.5–2.

(b) Lighting energy profiles are shown in Table 11–3 that establish the percentage of the lighting load switched-on in each Prototype or Reference Building by hour of the day. These profiles are default assumptions and can be changed when calculating the Energy Cost Budget to provide, for example, a 12 hour rather than an 8 hour work day.

11.5.4.2.3 Receptacles

(a) Receptacle loads and profiles are default assumptions. The same assumptions shall be made in calculating Design Energy Consumption as were used in calculating the Energy Cost Budget.

(b) Receptacle loads include all general service loads that are typical in a building. These loads exclude any process electrical usage and HVAC primary or auxiliary electrical usage. Table 11–4, Receptacle Power Densities, establishes the density, in W/ft^2, to be used for each building type. The receptacle energy profiles shall be the same as the lighting energy profiles in Table 11–3. This profile establishes the percentage of the receptacle load that is switched on by hour of the day and by building type.

11.5.5 Building Exterior Envelope

11.5.5.1 Insulation and Glazing

11.5.5.1.1 The insulation and glazing characteristics of the Prototype and Reference Building envelope shall be determined by using the first column under ''Base Case'', with no assumed overhangs for the appropriate Alternate Component Tables (ACP) in section 5.0, as defined by climate range. The insulation and glazing characteristics from this ACP are Prescribed Assumptions for Prototype and Reference Buildings for calculating the Energy Cost Budget. In calculating the Design Energy Consumption of the Proposed Design, the envelope characteristics of the Proposed Design shall be used.

11.5.5.2 Infiltration

11.5.5.2.1 For Prototype and Reference Buildings, infiltration assumptions shall be prescribed assumptions for calculating the Energy Cost Budget and default assumptions for the Design Energy Consumption. Infiltration shall impact perimeter zones only.

11.5.5.2.2 When the HVAC system is switched ''on'', no infiltration shall be assumed. When the HVAC system is switched ''off'', the infiltration rate for buildings with or without operable windows shall be assumed to be 0.038 cfm/ft^2 of gross exterior wall. Hotels/motels and multi-family high rise residential buildings shall have infiltration rates of 0.038 cfm/ft^2 of gross exterior wall area at all times.

11.5.5.3 Envelope and Ground Absorptivities

11.5.5.3.1 For Prototype and Reference Buildings, absorptivity assumptions shall be prescribed assumptions for computing the Energy Cost Budget and default assumptions for computing the Design Energy Consumption. The solar absorptivity of opaque elements of the building envelope is assumed to be 70%. The solar absorptivity of ground surfaces is assumed to be 80% (20% reflectivity).

11.5.5.4 Window Management

11.5.5.4.1 For the Prototype and Reference Building, window management drapery assumptions shall be prescribed assumptions for setting the Energy Cost Budget. No draperies shall be the default assumption for computing the Design Energy Consumption. Glazing is assumed to be internally shaded by medium-weight draperies, closed one-half time. The draperies shall be modeled by assuming that one-half the area in each zone is draped and one-half is not. If manually-operated draperies, shades, or blinds are to be used in the Proposed Design, the Design Energy Consumption shall be calculated by assuming they are effective over one-half the glazing area in each zone.

11.5.5.5 Shading

11.5.5.5.1 For Prototype and Reference buildings and the Proposed Design, shading by permanent structures, terrain, and vegetation shall be taken into account for computing energy consumption, whether or not these features are located on the building site. A permanent fixture is one that is likely to remain for the life of the Proposed Design.

11.5.6 HVAC Systems and Equipment

11.5.6.1 The specifications and requirements for the HVAC systems of the Prototype and Reference Buildings shall be those in Table 11–5, HVAC Systems for Prototype and Reference Buildings. For the calculation of the Design Energy Consumption, the HVAC systems and equipment of the Proposed Design shall be used.

11.5.6.2 The systems and types of energy presented in Table 11–5 are intended only as constraints in calculating the Energy Cost Budget. They are not intended as either requirements or recommendations for either systems or the type of energy to be used in the Proposed Building or for the calculation of the Design Energy Cost.

11.5.6.3 HVAC Zones

11.5.6.3.1 HVAC zones for calculating the Energy Cost Budget of the Prototype or Reference Building shall consist of at least four perimeter and one interior zones per floor. Prototype Buildings shall have one perimeter zone facing each cardinal direction. The perimeter zones of Prototype and Reference Buildings shall be 15 ft in width, or one-third the narrow dimension of the building, when this dimension is between 30 ft and 45 ft inclusive, or one-half the narrow dimension of the building when this dimension is less than 30 ft. Zoning requirements shall be a default assumption for calculating the Energy Cost Budget. For multi-family high rise residential buildings, the prototype building shall have one zone per dwelling unit. The proposed design shall have one zone per unit unless zonal thermostatic controls are provided within units; in this case, two zones per unit shall be modeled. Building types such as assembly or warehouse may be modeled as a single zone if there is only one space.

11.5.6.3.2 For calculating the Design Energy Consumption, no fewer zones shall be used than were in the Prototype and Reference Buildings. The zones in the simulation shall correspond to the zones provided by the controls in the Proposed Design. Thermally similar zones, such as those facing one orientation on different floors, may be grouped together for the purposes of either the Design Energy Consumption or Energy Cost Budget simulation.

11.5.6.4 Equipment Sizing and Redundant Equipment

11.5.6.4.1 For calculating the Energy Cost Budget of Prototype or Reference Buildings, HVAC equipment shall be sized to meet the requirements of section 7.3.2, without using any of the exceptions. The size of equipment shall be that required for the building without process loads considered. The designer shall determine the final equipment sizing including the process loads by separate calculations. Redundant and/or emergency equipment need not be simulated if it is controlled so that it will not be operated during normal operations of the building. The designer shall document the installation of process equipment and the size of process loads.

11.5.6.4.2 For calculating the Design Energy Consumption, actual air flow rates and installed equipment size shall be used in the simulation, except that excess capacity provided to meet process loads need not be modeled if the process load was not modeled in setting Energy Cost Budget. Equipment sizing in the simulation of the Proposed Design shall correspond to the equipment actually selected for the design and the designer shall not use equipment sized automatically by the simulation tool.

11.5.6.4.3 Redundant and/or emergency equipment need not be simulated if it is controlled to not be operated during normal operations of the building.

11.5.7 Service Water Heating

11.5.7.1 The service water loads for Prototype and Reference Buildings are defined in terms of Btu/h per person in Table 11–6. The service water heating loads from Table 11–6 are prescribed assumptions for multi-family high rise residential buildings and default assumptions for all other buildings. The same service water heating load assumptions shall be made in calculating Design Energy Consumption as were used in calculating the Energy Cost Budget.

11.5.7.2 The service water heating system, including piping losses for the Prototype Building, shall be modeled using the methods of the *ASHRAE Handbook, 1987 HVAC Systems and Applications Volume* using a system that meets all requirements of section 9.0. The service water heating equipment for the Prototype or Reference Building shall be either natural gas or #2 fuel oil, if natural gas is not available at the site, or an electric heat pump.

11.5.7.3 *Exception to section 11.5.7:*

11.5.7.3.1 If electric resistance service water heating is preferable to an electric heat pump when analyzed according to the criteria of section 9.3.7.1

or when service water temperatures exceeding 145 °F are required for a particular application, electric resistance water heating may be used.

11.5.8 Controls

11.5.8.1 All occupied conditioned spaces in the Prototype, Reference and Proposed Design Buildings in all climates shall be simulated as being both heated and cooled. The assumptions in this subsection are prescribed assumptions. If the Proposed Design does not include equipment for cooling or heating, the Design Energy Consumption shall be determined by the specifications for calculating the Energy Cost Budget as described in Table 11–7.

11.5.8.2 *Exceptions to section 11.5.8:*

11.5.8.2.1 If a building is to be provided with only heating or cooling, both the Prototype or Reference Building and the Proposed Design shall be simulated, using the same assumptions. If such an assumption is made, the analysis shall show that the building interior temperature meets the comfort criteria of *ANSI/ASHRAE 55–1981* ''Thermal Environmental Conditions for Human Occupancy,'' at least 98% of the occupied hours during the year.

11.5.8.2.2 If warehouses are not intended to be mechanically cooled, both the Energy Cost Budget and Design Energy Consumption shall be modeled assuming no mechanical cooling; and

11.5.8.2.3 In climates where winter design temperature (97.5% occurrence) is greater than 59 °F, space heating need not be modeled.

11.5.8.3 Space temperature controls for the Prototype or Reference Building, except multi-family high rise residential buildings shall be set at 70 °F for space heating and 75 °F for space cooling with a deadband per section 7.3.4.5. The system shut off during off-hours shall be according to the schedule in Table 11–3, except that the heating system shall cycle on if any space should drop below the night setback setting of 55 °F. There shall be no similar setpoint during the cooling season. Lesser deadband ranges may be used in calculating the Design Energy Consumption.

11.5.8.3.1 *Exceptions to section 11.5.8.3:*

(a) Setback shall not be modeled in determining either the Energy Cost Budget or Design Energy Cost if setback is not realistic for the Proposed Design, such as 24 hour/day operations. Health facilities need not have night setback during the heating season;

(b) Hotel/motels and multi-family high rise residential buildings shall have a night setback temperature of 60 °F from 11:00 p.m. to 6:00 a.m. during the heating season; and

(c) If deadband controls are not to be installed, the Design Energy Cost shall be calculated with both heating and cooling thermostat setpoints set to the same value between 70 °F and 75 °F inclusive, assumed to be constant for the year.

11.5.8.3.2 For multi-family buildings, the thermostat schedule for the dwelling units shall be as in Table 11–8.

(a) The Prototype Building shall use the single zone schedule. The Proposed Design shall use the two-zone schedule only if zonal thermostatic controls are provided. For Proposed Designs that use heat pumps employing supplementary heat, the controls used to switch on the auxiliary heat source during morning warm-up periods shall be simulated accurately. The thermostat assumptions for multi-family high-rise buildings are prescribed assumptions.

11.5.8.4 When providing for outdoor air ventilation in calculating the Energy Cost Budget, controls shall be assumed to close the outside air intake to reduce the flow of outside air to 0 cfm during setback and unoccupied periods. Ventilation using inside air may still be required to maintain scheduled setback temperature. Outside air ventilation, during occupied periods, shall be as required by *ASHRAE Standard 62–1981,* ''Ventilation for Acceptable Indoor Air,'' or the Proposed Design, whichever is greater.

11.5.8.5 If humidification is to be used in the Proposed Design, the same level of humidification and system type shall be used in the Prototype or Reference Building. If dehumidification requires subcooling of supply air, then reheat for the Prototype or Reference Building shall be from recovered waste heat such as condenser waste heat.

11.5.9 Speculative Buildings

11.5.9.1 Lighting

11.5.9.1.1 The interior lighting power allowance (ILPA) for calculating the Energy Cost Budget shall be determined from Table 3.4–1. The Design Energy Consumption may be based on an assumed adjusted lighting power for future lighting improvements.

(a) The assumption about future lighting power used to calculate the Design Energy Consumption must be documented so that the future installed lighting systems may be in compliance with these standards. Documentation must be provided to enable future lighting systems to use either the Prescriptive method of section 3.4 or the Systems Performance method of section 3.5.

(b) Documentation for future lighting systems that use the Prescriptive method of section 3.4 shall be stated as a maximum adjusted lighting power for the tenant spaces. The adjusted lighting power allowance for tenant spaces shall account for the lighting power provided for the common areas of the building.

(c) Documentation for future lighting systems that use the System Performance method of section 3.5 shall be stated as a required lighting adjustment. The required lighting adjustment is the whole building lighting power assumed in order to calculate the Design Energy Consumption minus the ILPA value from Table 3.4–1 that was used to calculate the Energy Cost Budget. When the required lighting adjustment is less than zero, a complete lighting design must be developed for one or more representative tenant spaces, demonstrating acceptable lighting within the limits of the assumed lighting power allowance.

11.5.9.2 HVAC Systems and Equipment

11.5.9.2.1 If the HVAC system is not completely specified in the plans, the Design Energy Consumption shall be based on reasonable assumptions about the construction of future HVAC systems and equipment. These assumptions shall be documented so that future HVAC systems and equipment may be in compliance with these standards.

11.6 The Simulation Tool

11.6.1 Annual energy consumption shall be simulated with a multi-zone, 8760 hours per year building energy model. The model shall account for:

11.6.1.1 The dynamic heat transfer of the building envelope such as solar and internal gains;

11.6.1.2 Equipment efficiencies as a function of load and climate;

11.6.1.3 Lighting and HVAC system controls and distribution systems by simulating the whole building;

11.6.1.4 The operating schedule of the building including night setback during various times of the year; and

11.6.1.5 Energy consumption information at a level necessary to determine the Energy Cost Budget and Design Energy Cost through the appropriate utility rate schedules.

11.6.2 While the simulation tool should simulate an entire year on an hour by hour basis (8760 hours), programs that approximate this dynamic analysis procedure and provide equivalent results are acceptable.

11.6.3 Simulation tools shall be selected for their ability to simulate accurately the relevant features of the building in question, as shown in the tool's documentation. For example, a single zone model shall not be used to simulate a large, multi-zone building, and a steady-state model such as the degree-day method shall not be used to simulate buildings when equipment efficiency or performance is significantly affected by the dynamic patterns of weather, solar radiation, and occupancy. Relevant energy-related features shall be addressed by a model such as daylighting, atriums or sunspaces, night ventilation or thermal storage, chilled water storage or heat recovery, active or passive solar systems, zoning and controls of heating and cooling systems, and ground-coupled buildings. In addition, models shall be capable of translating the Design Energy Consumption into energy cost using actual utility rate schedules with the coincidental electrical demand of a building. Examples of public domain models capable of handling such complex building systems and energy cost translations available in the United States are DOE–2.1C and

BLAST 3.0 and in Canada, Energy Systems Analysis Series.

11.6.4 All simulation tools shall use scientifically justifiable documented techniques and procedures for modeling building loads, systems, and equipment. The algorithms used in the program shall have been verified by comparison with experimental measurements, loads, systems, and equipment.

TABLE 11-1

MULTI-FAMILY HIGH RISE RESIDENTIAL BUILDING SCHEDULES

(INTERNAL LOADS PER DWELLING UNIT Btu/h)

One-Zone Dwelling Unit

HOUR	OCCUPANTS SENSIBLE	OCCUPANTS LATENT	LIGHTS SENSIBLE	EQUIPMENT SENSIBLE	EQUIPMENT LATENT
1	300	260	0	750	110
2	300	260	0	750	110
3	300	260	0	750	110
4	300	260	0	750	110
5	300	260	0	750	110
6	300	260	0	750	110
7	300	260	980	1250	190
8	210	200	840	2600	420
9	100	80	0	1170	180
10	100	80	0	1270	190
11	100	80	0	1270	190
12	100	80	0	2210	330
13	100	80	0	2210	330
14	100	80	0	1270	190
15	100	80	0	1270	190
16	100	80	0	1270	190
17	100	80	0	1270	190
18	300	260	0	3040	450
19	300	260	0	3360	500
20	300	260	960	1490	220
21	300	260	960	1490	220
22	300	260	960	1490	220
23	300	260	960	1060	160
24	300	260	960	1060	160

TABLE 11-1 (CONT.)
MULTI-FAMILY HIGH RISE RESIDENTIAL BUILDING SCHEDULES
(INTERNAL LOADS PER DWELLING UNIT Btu/h)

Two-Zone Dwelling Unit

HOUR	BEDROOMS & BATHROOMS					OTHER ROOMS				
	OCCUPANTS		LIGHTS	EQUIPMENT		OCCUPANTS		LIGHTS	EQUIPMENT	
	Sensible	Latent	Sensible	Sensible	Latent	Sensible	Latent	Sensible	Sensible	Latent
1	300	260	0	100	20	0	0	0	650	90
2	300	260	0	100	20	0	0	0	650	90
3	300	260	0	100	20	0	0	0	650	90
4	300	260	0	100	20	0	0	0	650	90
5	300	260	0	100	20	0	0	0	650	90
6	300	260	0	100	20	0	0	0	650	90
7	200	180	680	200	40	100	80	300	1050	150
8	110	120	240	200	40	100	80	600	2400	380
9	0	0	0	100	20	100	80	0	1070	160
10	0	0	0	100	20	100	80	0	1170	170
11	0	0	0	100	20	100	80	0	1170	170
12	0	0	0	100	20	100	80	0	2110	310
13	0	0	0	100	20	100	80	0	2110	310
14	0	0	0	100	20	100	80	0	1170	170
15	0	0	0	100	20	100	80	0	1170	170
16	0	0	0	100	20	100	80	0	1170	170
17	0	0	0	100	20	100	80	0	1170	170
18	0	0	0	100	20	300	260	0	2940	430
19	0	0	0	100	20	300	260	0	3260	480
20	100	80	320	300	60	200	180	640	1190	160
21	100	80	320	300	60	200	180	640	1190	160
22	150	130	480	700	90	150	130	480	790	130
23	300	260	640	410	70	0	0	320	650	90
24	300	260	640	410	70	0	0	320	650	90

TABLE 11-2
OCCUPANCY DENSITY

BUILDING TYPE	CONDITIONED FLOOR AREA Ft^2/PERSON
Assembly	50
Office	275
Retail	300
Warehouse	15000
School	75
Hotel/Motel	250
Restaurant	100
Health/Institutional	200
Multi-family High Rise Residential	2 per unit[1]

Heat generation: Btu/h per person: 230 Btu/h per person sensible, and 190 Btu/h per person latent.

1. See Table 11-1

TABLE 11-3

BUILDING SCHEDULE PERCENTAGE MULTIPLIERS

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
ASSEMBLY OCCUPANCY	WEEKDAY:	0	0	0	0	0	0	0	0	20	20	20	20	80	80	80	80	80	80	20	20	20	20	10	0
	SATURDAY:	0	0	0	0	0	0	0	0	20	20	20	20	60	60	60	60	60	60	60	60	60	80	10	0
	SUNDAY:	0	0	0	0	0	0	0	0	10	10	10	10	10	70	70	70	70	70	70	70	70	70	20	0
ASSEMBLY LTNG & RECEP	WEEKDAY:	0	0	0	0	0	0	40	40	40	75	75	75	75	75	75	75	75	75	75	75	75	75	25	0
	SATURDAY:	0	0	0	0	0	0	0	30	30	50	50	50	50	50	50	50	50	50	50	50	50	50	0	0
	SUNDAY:	0	0	0	0	0	0	0	30	30	30	30	30	65	65	65	65	65	65	65	65	65	65	0	0
ASSEMBLY HVAC	WEEKDAY:	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	OFF
	SATURDAY:	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	OFF
	SUNDAY:	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	OFF
ASSEMBLY SWH	WEEKDAY:	0	0	0	0	0	0	0	0	0	5	5	35	5	5	5	5	5	0	0	0	0	0	0	0
	SATURDAY:	0	0	0	0	0	0	0	0	0	5	5	20	0	0	0	0	0	0	0	65	30	0	0	0
	SUNDAY:	0	0	0	0	0	0	0	0	0	5	5	10	0	0	0	0	0	0	0	65	30	0	0	0
OFFICE OCCUPANCY	WEEKDAY:	0	0	0	0	0	0	0	10	20	95	95	45	45	95	95	95	95	95	30	10	10	10	0	0
	SATURDAY:	0	0	0	0	0	0	0	10	10	30	30	30	30	10	10	10	10	10	0	0	0	0	0	0
	SUNDAY:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OFFICE LTNG & RECEP	WEEKDAY:	0	0	0	0	0	0	10	30	90	90	90	90	80	90	90	90	90	90	30	30	20	20	0	0
	SATURDAY:	0	0	0	0	0	0	10	10	30	30	30	30	15	15	15	15	15	15	0	0	0	0	0	0
	SUNDAY:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OFFICE HVAC	WEEKDAY:	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF
	SATURDAY:	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	ON	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
	SUNDAY:	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
OFFICE SWH	WEEKDAY:	0	0	0	0	0	0	0	15	30	35	35	45	55	50	30	30	40	20	20	10	15	5	0	0
	SATURDAY:	0	0	0	0	0	0	0	10	10	20	15	20	15	15	10	10	10	0	0	0	0	0	0	0
	SUNDAY:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 11-3 (Continued)
BUILDING SCHEDULE PERCENTAGE MULTIPLIERS

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
RETAIL	WEEKDAY:	0	0	0	0	0	0	0	10	20	50	50	70	70	70	70	80	70	50	50	30	30	0	0	0
OCCUPANCY	SATURDAY:	0	0	0	0	0	0	0	10	20	50	60	80	80	80	80	80	80	60	20	20	20	10	0	0
	SUNDAY:	0	0	0	0	0	0	0	0	0	10	20	20	40	40	40	40	40	20	10	0	0	0	0	0
RETAIL	WEEKDAY:	0	0	0	0	0	0	0	20	50	90	90	90	90	90	90	90	90	90	60	60	50	0	0	0
LTNG & RECEP	SATURDAY:	0	0	0	0	0	0	0	10	30	60	90	90	90	90	90	90	90	90	50	30	30	10	0	0
	SUNDAY:	0	0	0	0	0	0	0	0	0	10	40	40	60	60	60	60	60	40	20	0	0	0	0	0
RETAIL	WEEKDAY:	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	OFF	OFF	OFF
HVAC	SATURDAY:	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	OFF	OFF
	SUNDAY:	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	OFF	OFF	OFF	OFF	OFF
RETAIL	WEEKDAY:	0	0	0	0	0	0	0	10	20	30	40	55	60	60	45	40	45	45	40	30	30	0	0	0
SWH	SATURDAY:	0	0	0	0	0	0	0	15	20	25	40	50	55	55	45	45	45	45	40	35	25	20	0	0
	SUNDAY:	0	0	0	0	0	0	0	0	0	10	25	30	35	35	30	30	35	30	20	0	0	0	0	0
WAREHOUSE	WEEKDAY:	0	0	0	0	0	0	0	15	70	90	90	90	50	85	85	85	20	0	0	0	0	0	0	0
OCCUPANCY	SATURDAY:	0	0	0	0	0	0	0	0	20	20	20	20	10	10	10	10	0	0	0	0	0	0	0	0
	SUNDAY:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WAREHOUSE	WEEKDAY:	0	0	0	0	0	0	0	40	70	90	90	90	90	90	90	90	90	0	0	0	0	0	0	0
LTNG & RECEP	SATURDAY:	0	0	0	0	0	0	0	0	10	25	25	25	10	10	10	10	0	0	0	0	0	0	0	0
	SUNDAY:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WAREHOUSE	WEEKDAY:	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF
HVAC	SATURDAY:	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	ON	ON	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
	SUNDAY:	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
WAREHOUSE	WEEKDAY:	0	0	0	0	0	0	0	5	25	35	35	45	55	50	35	50	15	0	0	0	0	0	0	0
SWH	SATURDAY:	0	0	0	0	0	0	0	0	0	10	10	15	0	0	0	0	0	0	0	0	0	0	0	0
	SUNDAY:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 11-3 (Continued)
BUILDING SCHEDULE PERCENTAGE MULTIPLIERS

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
SCHOOL	WEEKDAY:	0	0	0	0	0	0	0	5	75	90	90	80	80	80	80	45	15	5	15	20	20	10	0	0
OCCUPANCY	SATURDAY:	0	0	0	0	0	0	0	0	10	10	10	10	10	0	0	0	0	0	0	0	0	0	0	0
	SUNDAY:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SCHOOL	WEEKDAY:	0	0	0	0	0	0	0	30	85	95	95	95	80	80	80	70	50	50	35	35	35	30	0	0
LTNG & RECEP	SATURDAY:	0	0	0	0	0	0	0	0	15	15	15	15	15	0	0	0	0	0	0	0	0	0	0	0
	SUNDAY:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SCHOOL	WEEKDAY:	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
HVAC	SATURDAY:	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
	SUNDAY:	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
SCHOOL	WEEKDAY:	0	0	0	0	0	0	0	5	30	55	60	70	75	80	60	60	5	5	15	20	20	20	0	0
SWH	SATURDAY:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SUNDAY:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HOTEL/MOTEL	WEEKDAY:	90	90	90	90	90	90	70	40	40	20	20	20	20	20	20	30	50	50	50	70	70	80	90	90
OCCUPANCY	SATURDAY:	90	90	90	90	90	90	70	50	50	30	30	30	30	30	30	30	30	50	60	60	60	70	70	70
	SUNDAY:	70	70	70	70	70	70	70	70	50	50	50	30	30	20	20	20	30	40	40	60	60	80	80	80
HOTEL/MOTEL	WEEKDAY:	20	15	10	10	10	20	40	50	40	40	25	25	25	25	25	25	25	25	60	80	90	80	60	30
LTNG & RECEP	SATURDAY:	20	20	10	10	10	10	30	30	40	40	30	25	25	25	25	25	25	25	60	70	70	70	60	30
	SUNDAY:	30	30	20	20	20	20	30	40	40	30	30	30	30	20	20	20	20	20	50	70	80	60	50	30
HOTEL/MOTEL	WEEKDAY:	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
HVAC	SATURDAY:	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
	SUNDAY:	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
HOTEL/MOTEL	WEEKDAY:	20	15	15	15	20	25	50	60	55	45	40	45	40	35	30	30	30	40	55	60	50	55	45	25
SWH	SATURDAY:	20	15	15	15	20	25	40	50	50	50	45	50	50	45	40	40	34	40	55	55	50	55	40	30
	SUNDAY:	25	20	20	20	20	30	50	50	50	55	50	50	40	40	30	30	30	40	50	50	40	50	40	20

TABLE 11-3 (Continued)

BUILDING SCHEDULE PERCENTAGE MULTIPLIERS

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
RESTAURANT OCCUPANCY	WEEKDAY:	15	15	5	0	0	0	0	5	5	5	20	50	80	70	40	20	25	50	80	80	80	50	35	20
	SATURDAY:	30	25	5	0	0	0	0	0	0	5	20	45	50	50	35	30	30	30	70	90	70	65	55	35
	SUNDAY:	20	20	5	0	0	0	0	0	0	0	0	20	25	25	15	20	25	35	55	65	70	35	20	20
RESTAURANT LTNG & RECEP	WEEKDAY:	15	15	15	15	15	20	40	40	60	60	90	90	90	90	90	90	90	90	90	90	90	90	50	30
	SATURDAY:	20	15	15	15	15	15	30	30	60	60	80	80	80	80	80	80	80	90	90	90	90	90	50	30
	SUNDAY:	20	15	15	15	15	15	30	30	50	70	70	70	70	70	70	70	60	60	60	60	60	60	50	30
RESTAURANT HVAC	WEEKDAY:	ON	ON	ON	OFF	OFF	OFF	OFF	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
	SATURDAY:	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
	SUNDAY:	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
RESTAURANT SWH	WEEKDAY:	20	15	15	0	0	0	0	60	55	45	40	45	40	35	30	30	30	40	55	60	50	55	45	25
	SATURDAY:	20	15	15	0	0	0	0	0	0	50	45	50	50	45	40	40	35	40	55	55	50	55	40	30
	SUNDAY:	25	20	20	0	0	0	0	0	0	0	50	50	40	40	30	30	30	40	50	50	40	50	40	20
HEALTH OCCUPANCY	WEEKDAY:	0	0	0	0	0	0	0	10	50	80	80	80	80	80	80	80	80	50	30	30	20	20	0	0
	SATURDAY:	0	0	0	0	0	0	0	10	30	40	40	40	40	40	40	40	40	10	10	0	0	0	0	0
	SUNDAY:	0	0	0	0	0	0	0	0	5	5	5	5	5	5	5	5	5	0	0	0	0	0	0	0
HEALTH LTNG & RECEP	WEEKDAY:	0	0	0	0	0	0	0	50	90	90	90	90	90	90	90	90	90	30	30	30	30	30	0	0
	SATURDAY:	0	0	0	0	0	0	0	20	40	40	40	40	40	40	40	40	40	40	10	0	0	0	0	0
	SUNDAY:	0	0	0	0	0	0	0	0	10	10	10	10	10	10	10	10	0	0	0	0	0	0	0	0
HEALTH SWH	WEEKDAY:	0	0	0	0	0	0	0	15	55	65	75	80	70	80	75	70	60	40	15	15	15	5	0	0
	SATURDAY:	0	0	0	0	0	0	0	0	15	25	25	25	20	20	20	20	20	5	0	0	0	0	0	0
	SUNDAY:	0	0	0	0	0	0	0	0	0	15	15	15	15	15	15	0	0	0	0	0	0	0	0	0
HEALTH HVAC	WEEKDAY:	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
	SATURDAY:	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
	SUNDAY:	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
MULTI-FAMILY SWH SYSTEM	WEEKDAY:	0	0	0	5	5	5	80	70	50	40	20	20	25	25	50	50	70	70	35	20	15	15	5	0
	SATURDAY:	0	0	0	0	0	0	20	45	50	50	35	30	30	30	70	90	70	65	55	35	30	25	5	0
	SUNDAY:	0	0	0	0	0	0	0	20	25	25	15	20	25	35	55	65	70	35	20	20	20	20	5	0

NOTES FOR TABLE 11-3

1 Reference: Recommendations for Energy Conservation Standards and Guidelines for New Commercial Buildings, Vol. III, App. A Pacific Northwest Laboratory, PNL-4870-8, 1983."

2 Table 11-3 contains multipliers for converting the nominal values for building occupancy (Table 11-2), receptacle power density (Table 11-4), service hot water (Table 11-6), and lighting energy (Section 3.4 or 3.5) into time series data for estimating building loads under the Standard Calculation Procedure.

For each standard building profile there are three series - one each for weekdays, Saturday and Sunday. There are 24 elements per series. These represent the multiplier that should be used to estimate building loads from 12 a.m. to 1 a.m. (series element #1) through 11 p.m. to 12 a.m. (series element #24). The estimated load for any hour is simply the multiplier from the appropriate standard profile multiplied by the appropriate value from the tables cited above.

3 The Building HVAC System Schedule listed in Table 11-3 lists the hours when the HVAC system shall be considered "on" or "off" in accordance with Section 11.5.5.2.

TABLE 11-4
RECEPTACLE POWER DENSITIES

BUILDING TYPE	W/ft^2 OF CONDTIONED FLOOR AREA
Assembly	0.25
Office	0.75
Retail	0.25
Warehouse	0.1
School	0.5
Hotel/Motel	0.25
Restaurant	0.1
Health	1.0
Multi-Family High Rise Residential	Included in Lights and Equipment portions of Table 11-1

TABLE 11-5
HVAC SYSTEMS OF PROTOTYPE AND REFERENCE BUILDINGS[1, 2]

BUILDING/SPACE OCCUPANCY	SYSTEM NO. (TABLE 11-7)	REMARKS (TABLE 11-7)
Assembly		
a. Churches (any size)	1	
b. ≤50,000 ft^2 or ≤3 floors	1 or 3	Note 1
c. >50,000 ft^2 or >3 floors	3	
Office		
a. ≤20,000 ft^2	1	
b. >20,000 ft^2 and either ≤3 floors or ≤75,000 ft^2	4	
c. >75,000 ft^2 or >3 floors	5	
Retail		
a. ≤50,000 ft^2	1 or 3	Note 1
b. >50,000 ft^2	4 or 5	Note 1
Warehouse	1	Note 1
Schools		
a. ≤75,000 ft^2 or ≤3 floors	1	
b. >75,000 ft^2 or >3 floors	3	
Hotel/Motel		
a. ≤3 stories	2 or 7	Note 5, 7
b. >3 stories	6	Note 6
Restaurant	1 or 3	Note 1
Health		
a. Nursing Home (any size)	2 or 7	Note 7
b. ≤15,000 ft^2	1	
c. >15,000 ft^2 and ≤50,000 ft^2	4	Note 2
d. >50,000 ft^2	5	Note 2, 3
Multi-Family High Rise Residential >3 stories	7	

1 Space and Service Water Heating budget calculations shall be made using both electricity and natural gas. The Energy Cost Budget shall be the lower of these two calculations. If natural gas is not available at the rate, electricity and #2 fuel oil shall be used for the budget calculations.

2 The systems and energy types presented in this Table are not intended as requirements or recommendations for the proposed design. Floor areas below are the total conditioned floor areas for the listed occupancy type in the building. The number of floors indicated below is the total number of occupied floors for the listed occupancy type.

TABLE 11-6
SERVICE HOT WATER QUANTITIES

Building Type	Btu/Person-hour[1]
1. Assembly	215
2. Office	175
3. Retail	135
4. Warehouse	225
5. School	215
6. Hotel/Motel	1110
7. Restaurant	390
8. Health	135
9. Multi-Family High Rise Residential	1700[2]

1. This value is the number to be multiplied by the percentage multipliers of the building profile schedules in Table 11-4. See Table 11-2 for occupancy levels.

2. Total hot water use per dwelling unit for each hour shall be 3400 Btu/h times the multi-family high rise residential building SWH system multiplier from Table 11-3.

TABLE 11-7
HVAC SYSTEM DESCRIPTION FOR PROTOTYPE AND REFERENCE BUILDINGS[1, 2]

HVAC COMPONENT	SYSTEM #1	SYSTEM #2	SYSTEM #3	SYSTEM #4
System Description	Packaged rooftop single zone, one unit per zone	Packaged terminal air conditioner with space heater or heatpump, one heating/cooling unit per zone	Air handler per zone with central plant	Packaged rooftop VAV w/perimeter reheat
Fan System Design supply circulation rate	Note 9	Note 10	Note 9	Note 9
Supply fan total static pressure	1.3 in. W.C.	N/A	2.0 in. W.C.	3.0 in. W.C.
Combined supply fan, motor, and drive efficiency	40%	N/A	50%	45%
Supply fan control	Constant volume	Fan Cycles with call for heating or cooling	Constant volume	VAV w/forward curved centrifugal fan and variable inlet vanes
Return fan total static pressure	N/A	N/A	0.6 in. W.C.	0.6 in. W.C.
Combined return fan, motor, and drive efficiency	N/A	N/A	25%	25%
Return fan control	N/A	N/A	Constant volume	VAV w/forward curved centrifugal fan and discharge dampers
Cooling System	Direct expansion air cooled	Direct expansion air cooled	Chilled water (Note 11)	Direct expansion air cooled
Heating System	Furnace, heatpump, or electric resistance (Note 8)	Heatpump w/electric resistance auxiliary or air conditioner w/space heater (Note 8)	Hot water (Note 8, 12)	Hot water (Note 12) or electric resistance (Note 8)
Remarks	Drybulb economizer per Section 7.4.3 (barometric relief)	No economizer	Drybulb economizer per Section 7.4.3	Drybulb economizer per Section 7.4.3 Minimum VAV setting per 7.4.3 exception 1. Supply air reset by zone of greatest cooling demand.

Notes:

1. The systems and energy types presented in this Table are not intended as requirements or recommendations for the proposed design.

2. For numbered notes see end of Table 11-7.

TABLE 11-7, (Continued)
HVAC SYSTEM DESCRIPTION FOR PROTOTYPE AND REFERENCE BUILDINGS[1]

HVAC COMPONENT	SYSTEM #5	SYSTEM #6	SYSTEM #7
System Description	Built-up central VAV with perimeter reheat	Four-pipe fan coil per zone with central plant	Water source heat pump
Fan System Design supply circulation rate	Note 9	Note 9	Note 10
Supply fan total static pressure	4.0 in. W.C.	0.5 in. W.C.	0.5 in. W.C.
Combined supply fan, motor, and drive efficiency	55%	25%	25%
Supply fan control	VAV w/air-foil centrifugal fan and AC frequency variable speed drive	Fan cycles w/call for heating or cooling	Fan cycles w/call for heating or cooling
Return fan total static pressure	1.0 in. W.C.	N/A	N/A
Combined return fan, motor, and drive efficiency	30%	N/A	N/A
Return fan control	VAV with air-foil centrifugal fan and AC frequency variable speed drive	N/A	N/A
Cooling System	Chilled water (Note 11)	Chilled water (Note 11)	Closed circuit, centrifugal centrifugal blower type cooling tower sized per Note 11. Circulating pump sized for 2.7 GPM per ton.
Heating System	Hot water (Note 12) or electric resistance (Note 8)	Hot water (Note 12) or electric resistance (Note 8)	Electric or natural draft fossil fuel boiler (Note 8)
Remarks	Drybulb economizer per Section 7.4.3 Minimum VAV setting per Section 7.4.4.3 Supply air reset by zone of greatest cooling demand.	No economizer	Tower fans and boiler cycled to maintain circulating water temperature between 60 and design tower leaving water temperature.

TABLE 11-7

NUMBERED NOTES FOR TABLE 11-7

HVAC SYSTEM DESCRIPTIONS FOR PROTOTYPE AND REFERENCE BUILDINGS

NOTES:

1. For occupancies such as restaurants, assembly and retail which are part of a mixed use building which, according to Table 11-7, includes a central chilled water plant (systems 3, 5, or 6), chilled water system type 3 or 5, as indicated in the Table, shall be used.

2. Constant volume may be used in zones where pressurization relationships must be maintained by code. VAV shall be used in all other areas, in accordance with Section 7.4.4.3.

3. Provide run-around heat recovery systems for all fan systems with minimum outside air intake greater than 75%. Recovery effectiveness shall be 0.60.

4. If a warehouse is not intended to be mechanically cooled, both the Energy Cost Budgets and Design Energy Costs, may be calculated assuming no mechanical cooling.

5. The system listed is for guest rooms only. Areas such as public areas and back-of-house areas shall be served by system 4. Other areas such as offices and retail shall be served by the systems listed in Table 11-7 for these occupancy types.

6. The system listed is for guest rooms only. Areas such as public areas and back-of-house areas shall be served by system 5. Other areas such as offices and retail shall be served by systems listed in Table 11-7 for these occupancy types.

7. System 2 shall be used for the Energy Cost Budget calculation except in areas with design heating outside air temperatures less than 10 ^{o}F.

8. Prototype energy budget cost calculations shall be made using both electricity and natural gas. If natural gas is not available at the site, electricity and #2 fuel oil shall be used. The Energy Cost Budget shall be the lower of these results. Alternately, the Energy Cost Budget may be based on the fuel source that minimizes total operating, maintenance, equipment,

and installation costs for the prototype over the building lifetime. Equipment and installation cost estimates shall be prepared using professionally recognized cost estimating tools, guides, and techniques. The methods of analysis shall conform to those of Subpart A of 10 CFR 436. Energy costs shall be based on actual costs to the building as defined in this Section.

9. Design supply air circulation rate shall be based on a supply air to room air temperature difference of 20 °F. A higher supply air temperature may be used if required to maintain a minimum circulation rate of 4.5 air changes per hour or 15 cfm per person at design conditions to each zone served by the system. If return fans are specified, they shall be sized from the supply fan capacity less the required minimum ventilation with outside air, or 75% of the supply air capacity, whichever is larger. Except where noted, supply and return fans shall be operated continuously during occupied hours.

10. Fan Energy When included in the efficiency rating of the unit as defined in Section 7.4.4.3 need not be modeled explicitly for this system. The fan shall cycle with calls for heating or cooling.

11. Chilled water systems shall be modeled using a reciprocating chiller for systems with total cooling capacities less than 175 tons, and centrifugal chillers for systems with cooling capacities of 175 tons or greater. For systems with cooling of 600 tons or more, the Energy Cost Budget shall be calculated using two centrifugal chillers lead/lag controlled. Chilled water pumps shall be sized using a 12 °F temperature rise, from 44 °F to 56 °F, operating at 75 feet of head and and 65% combined impeller and motor efficiency. Condenser water pumps shall be sized using a 10 °F temperature rise, operating at 60 feet of head and 60% combined impeller and motor efficiency. The cooling tower shall be an open circuit, centrifugal blower type sized for the larger of 85 °F leaving water temperature or 10 °F approach to design wetbulb temperature. The tower shall be controlled to provide a 65 °F leaving water temperature whenever weather conditions permit, floating up to design leaving water temperature at design conditions. Chilled water supply temperature shall be reset in accordance with Section 7.4.6.2.

12. Hot water system shall include a natural draft fossil fuel or electric boiler per Note 8. The hot water pump shall be sized based on a 30 °F temperature drop, for 180 °F to 150 °F, operating at 60 feet of head and a combined impeller and motor efficiency of 60%. Hot water supply temperature shall be reset in accordance with Section 7.4.6.2.

TABLE 11-8
THERMOSTAT SETTINGS FOR MULTI-FAMILY HIGH-RISE BUILDINGS

TIME OF DAY	SINGLE ZONE DWELLING UNIT		TWO ZONE DWELLING UNIT			
			BEDROOMS/BATHROOMS		OTHER ROOMS	
	HEAT	COOL	HEAT	COOL	HEAT	COOL
Midnight - 6 a.m.	60	78	60	78	60	85
6 a.m. - 9 a.m.	70	78	70	78	70	78
9 a.m. - 5 p.m.	70	78	60	85	70	78
5 p.m. - 11 p.m.	70	78	70	78	70	78
11 p.m. - Midnight	60	78	60	78	60	78

§435.112 Building energy compliance alternative.

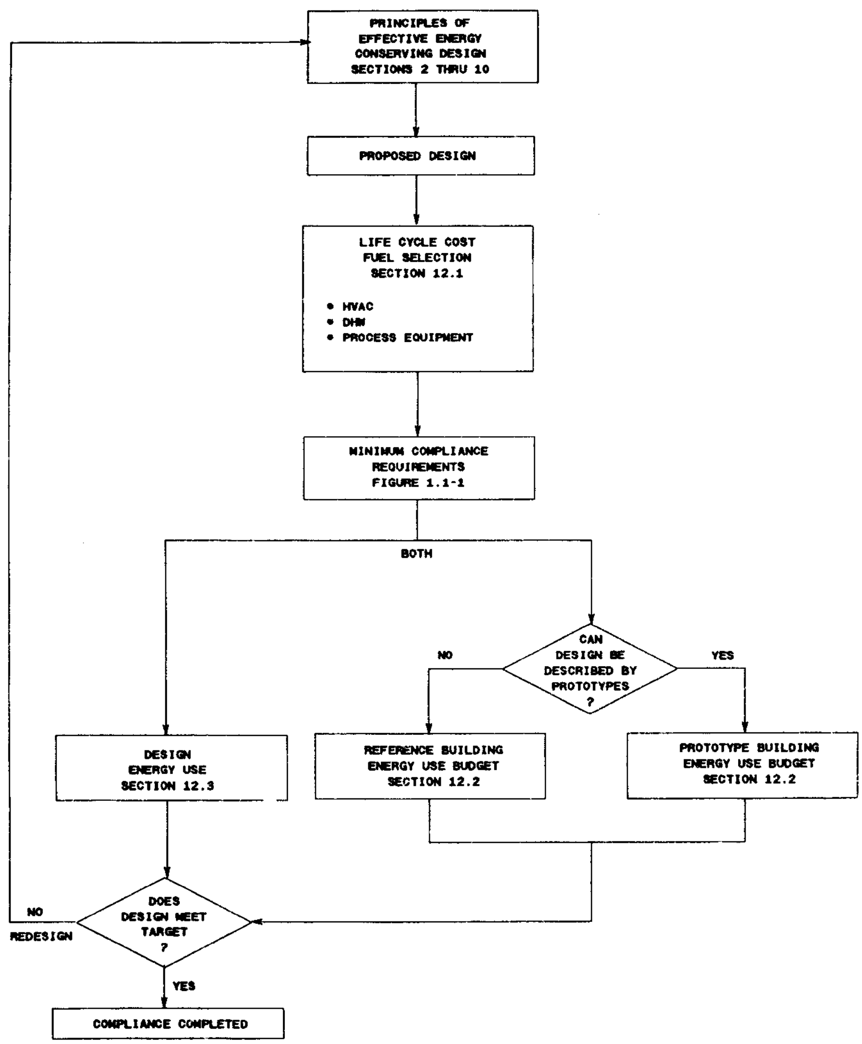
12.1 General

12.1 This section provides an alternative path for compliance with the standards that allow for greater flexibility in the design of energy efficient buildings using an annual energy target method. This path, as does the path used in section 11.0, provides an opportunity for the use of innovative designs, materials, and equipment such as daylighting, passive solar heating, heat recovery, and thermal storage as well as other applications of off-peak electrical energy where they cannot be adequately evaluated by the prescriptive or system performance methods found in sections 3.4, 3.5, 5.4, 5.5, 7.4., and 9.4.

12.1.2 The Building Energy Use Budget Target alternative may be used as an option to the Building Energy Cost Budget method in section 11.0 and is to be used in lieu of the prescriptive and system performance methods and in conjunction with sections 3.3, 4.3, 5.3, 6.3, 7.3, 8.3, 9.3 and 10.3.

12.1.3 Compliance under this section is demonstrated by showing that the calculated annual energy usage for the Proposed Design is less than or equal to a calculated Energy Use Budget. (See Figure 12–1). A life-cycle cost economic analysis is required to evaluate alternative fuel sources and energy reduction strategies. The procedures in this chapter are intended only for establishing design compliance, and are not intended to be used either to predict, document or verify annual energy consumption or annual energy costs.

Figure 12-1 Building Energy Compliance Alternative



12.1.4 Compliance under the Building Energy Use Budget method requires a detailed energy analysis, using a conventional simulation tool, of the Proposed Design. A life-cycle cost analysis shall be used to select the fuel source for the HVAC systems, service hot water, and process loads from available alternatives. The Annual Energy Consumption of the Proposed Design with the life-cycle cost-effective fuel selection is calculated to determine the modeled energy consumption, called the Design Energy Use.

12.1.5 The Design Energy Use is defined as the energy that is consumed within the five foot line of a proposed building per ft^2 over a 24 hour day, 365-day year period and specified operating hours. The calculated Design Energy

Use is then compared to a calculated Energy Use Budget.

12.1.6 *Compliance.* The Energy Use Budget is determined by calculating the annual energy usage for a Reference or Prototype Building that is configured to comply with the provisions of section 11.0 for such buildings, except that the fuel source(s) of the Prototype or Reference Building shall be the same life-cycle cost-effective source(s) selected for the Proposed Design. If the Design Energy Use is less than or equal to the Energy Use Budget then the proposed design complies with these standards.

12.1.7 This section provides instructions for determining the Design Energy Use and for calculating the Energy Use Budget. The Energy Use Budget is the highest allowable calculated annual energy consumption for a specified building design. Designers are encouraged to design buildings whose Design Energy Use is lower than the Energy Use Budget. Incorporated in this section is an optional life-cycle cost economic analysis procedure that may be used by the designer to examine the economic feasibility of all energy design alternatives and to produce a more optimum design.

12.2 Determination of the Annual Energy Budget

12.2.1 The Energy Use Budget shall be calculated for the appropriate Prototype or Reference Building in accordance with the procedures prescribed in section 11.2 with the following exceptions: The Energy Use Budget shall be stated in units of $Btu/ft^2 \cdot yr$ and the simulation tool shall segregate the calculated energy consumption by fuel type producing an Energy Use Budget for each fuel (the fuel selections having been made by a life cycle cost analysis in determining the proposed design).

12.2.2 The Energy Use Budget (EUB) is calculated similarly for the Reference or Prototype Building using the following equation:

$$EUB=EUB_1 \times f_1+EUB_2 \times f_2+ \ldots\ldots +EUB_i \times f_i$$

Equation 12–1

Where EUB_1, EUB_2, . . . EUB_i are the calculated annual energy targets for each fuel used in the Reference or Prototype building and f_1, f_2, . . . f_i are the energy conversion factors given in Table 12–1. In lieu of case by case calculation of the Energy Use Budget, the designer may construct Energy Use Budget tables for the combinations of energy source(s) that may be considered in a set of project designs, such as electric heating, electric service water, and gas cooling or oil heating, gas service water and electric cooling. The values in such optional Energy Use Budget tables shall be equal to or less than the corresponding Energy Use Budgets calculated on a case by case basis according to this section. Energy Use Budget tables shall be constructed to correspond to the climatic regions and building types in accordance with provisions for Prototype or Reference Building models in section 11.0 of these standards.

TABLE 12-1

FUEL CONVERSION FACTORS FOR COMPUTING DESIGN ANNUAL ENERGY USES

FUELS	CONVERSION FACTOR
Electricity	3412 Btu/kilowatt hour
Fuel Oil	138,700 Btu/gallon
Natural Gas	1,031,000 Btu/1000 ft^3
Liquified Petroleum (including Propane and Butane)	95,500 Btu/gallon
Anthracite Coal	28,300,000 Btu/short ton
Bituminous Coal	24,580,000 Btu/short ton
Purchased Steam and Steam from Central Plants	1,000 Btu/Pound
High Temperature or Medium Temperature Water from Central Plants	Use the heat value based on the water actually delivered at the building five foot line

NOTE: At specific locations where the energy source Btu content varies significantly from the value presented above then the local fuel value may be used provided there is supporting documentation from the fuel source supplier stating this actual fuel energy value and verifying that this value will remain consistent for the foreseeable future. The fuel content for fuels not given above shall be determined from the best available source.

12.3 Determination of the Design Energy Use

12.3.1 The Design Energy Use shall be calculated by modeling the Proposed Design using the same methods, assumptions, climate data, and simulation tool as were used to establish the Energy Use Budget, but with the design features that will be used in the final building design. The simulation tool used shall segregate the calculated energy consumption by fuel type giving an annual Design Energy Use for each fuel. The sum of the Design Energy Uses multiplied by the fuel conversion factors in Table 12–1 yields the Design Energy Use for the proposed design:

$$DEU = DEU_1 \times f_1 + DEU_2 \times f_2 + \ldots + DEU_i \times f_i$$

Equation 12–2

Where $f_1, f_2, \ldots f_i$ are the fuel conversion factors in Table 12–1.

12.3.2 Required Life Cycle Cost Analysis for Fuel Selection

12.3.2.1 Fuel sources selected for the Proposed Design and Prototype or Reference buildings shall be determined by considering the energy cost and other costs and benefits that occur during the expected economic life of the alternative.

12.3.2.2 The designer shall use the procedures set forth in subpart A of 10 CFR part 436 to make this determination. The fuel selection life cycle cost analysis shall include the following steps:

12.3.2.2.1 Determine the feasible alternatives for energy sources of the Proposed Design's HVAC systems, service hot water, and process loads.

12.3.2.2.2 Model the Proposed Design including the alternative HVAC and service water systems and conduct an annual energy analysis for each fuel source alternative using the simulation tool specified in this section. The annual energy analysis shall be computed on a monthly basis in conformance with section 11.0 of these standards with the exception that all process loads shall be included in the calculation. Separate the output of the analysis by fuel type.

12.3.2.2.3 Determine the unit price of each fuel using information from the utility or other reliable local source. During rapid changes in fuel prices it is recommended that an average fuel price for the previous twelve months be used in lieu of the current price. Calculate the annual energy cost of each energy source alternative in accordance with procedures in section 11.0 for the Design Energy Cost. Estimate the initial cost of the HVAC and service water systems and other initial costs such as energy distribution lines and service connection fees associated with each fuel source alternative. Estimate other costs and benefits for each alternative including, but not necessarily limited to, annual maintenance and repair, periodic and one time major repairs and replacements and salvage of the energy and service water systems. Cost estimates shall be prepared using professionally recognized cost estimating tools, guides and techniques.

12.3.2.2.4 Perform a life cycle cost analysis using the procedure specified in section 12.3.2.

12.3.2.2.5 Compare the total life cycle cost of each energy source alternative. The alternative with the lowest total life-cycle cost shall be chosen as the energy source for the proposed design.

12.4 Compliance

12.4.1 Compliance with this section is demonstrated if the Design Energy Use is equal to or less than the Energy Use Budget.

$$DEU \leq EUB$$

Equation 12–3

12.4.2 The energy consumption shall be measured at the building five foot line for all fuels. Energy consumed from non-depletable energy sources and heat recovery systems shall not be included in the Design Energy Use calculations. The thermal efficiency of fixtures, equipment, systems or plants in the proposed design shall be simulated by the selected calculation tool.

12.5 Standard Calculation Procedure

12.5.1 The Standard Calculation Procedure consists of methods and assumptions for calculating the Energy Use Budgets for Prototype and Reference Buildings and the Design Energy Use for the Proposed Design. In order to maintain consistency between the Energy Use Budgets and the Design Energy Use, the input assumptions stated in section 11.5 are to be used.

12.5.2 The terms Energy Cost Budget and Design Energy Cost or Consumption used in section 11.0 correlate to Energy Use Budget and Design Energy Use, respectively, in section 12.0.

12.6 The Simulation Tool

12.6.1 The criteria established in section 11.0 for the selection of a simulation tool shall be followed when using the compliance path prescribed in section 12.0.

12.7 Life Cycle Cost Analysis Criteria

12.7.1 The following life cycle cost criteria applies to the fuel selection requirements of this chapter and to option life cycle cost analyses performed to evaluate energy conservation design alternatives. The fuel source(s) selection shall be made in accordance with the requirements of subpart A of 10 CFR part 436. The implementation calculations for the methodology of subpart A of 10 CFR part 436 is provided in *National Bureau of Standards Handbook 135* entitled ''Life Cycle Cost Manual for the Federal Energy Management Program.'' When performing life cycle cost analyses of optional energy conservation opportunities the designer may use the life cycle cost procedures of *subpart A of 10 CFR part 436 or OMB Circular A–94* or an equivalent procedure that meets the assumptions listed below:

12.7.1.1 The economic life of the Prototype Building and Proposed Design shall be 25 years. Anticipated replacements or renovations of energy related features and systems in the Prototype or Reference Building and Proposed Design during this period shall be included in their respective life cycle cost calculations.

12.7.1.2 The designer shall follow established professional cost estimating practices when determining the costs and benefits associated with the energy related features of the Prototype or Reference Building and Proposed Design.

12.7.1.3 All costs shall be expressed in current dollars. General inflation shall be disregarded. Differential escalation of prices (prices estimated to rise faster or slower than general inflation) for energy used in the life cycle cost calculations shall be those in effect at the time of the life cycle cost calculations as published by the Department of Energy's Energy Information Administration.

12.7.1.4 The economic effects of taxes, depreciation and other factors not consistent with the practices of *subpart A of 10 CFR part 436* shall not be included in the life cycle cost calculation.

Subpart B—Voluntary Performance Standards for New Non-Federal Residential Buildings [Reserved]

Subpart C—Mandatory Performance Standards for New Federal Residential Buildings

§ 435.300 Purpose.

(a) This subpart establishes voluntary energy conservation performance standards for new residential buildings. The voluntary energy conservation performance standards are designed to achieve the maximum practicable improvements in energy efficiency and increases in the use of non-depletable sources of energy.

(b) Voluntary energy conservation performance standards prescribed under this subpart shall be developed solely as guidelines for the purpose of providing technical assistance for the design of energy conserving buildings, and shall be mandatory only for the design of Federal buildings.

(c) The energy conservation performance standards will direct Federal policies and practices to ensure that cost-effective energy conservation features will be incorporated into the designs of all new residential buildings designed and constructed by and for Federal agencies.

§ 435.301 Scope.

(a) The energy conservation performance standards for new Federal residential buildings will apply to the design of all new residential buildings except multifamily buildings more than three stories above grade.

(b) The primary types of buildings built by or for the Federal agencies, to which the energy conservation performance standards will apply, are:

(1) Single-story single-family residences;

(2) Split-level single-family residences;

(3) Two-story single-family residences;

(4) End-unit townhouses;

(5) Middle-unit townhouses;

(6) End-units in multifamily buildings (of three stories above grade or less);

(7) Middle-units in multifamily buildings (of three stories above grade or less);

(8) Single-section mobile homes; and

(9) Multi-section mobile homes.

§ 435.302 Definitions.

(a) *ANSI* means American National Standards Institute.

(b) *ASHRAE Handbook* means American Society of Heating, Refrigerating and Air-Conditioning Engineeers, Inc., ASHRAE Handbook, 1985 Fundamentals. Volume, 1–P Edition.

(c) *ASTM* means American Society of Testing and Measurement.

(d) *British thermal unit (Btu)* means approximately the amount of heat required to raise the temperature of one pound of water from 59°F to 60°F.

(e) *Building* means any new residential structure:

(1) That includes or will include a heating or cooling system, or both, or a domestic hot water system, and

(2) For which a building design is created after the effective date of this rule.

(f) *Building design* means the development of plans and specifications for human living space.

(g) *Conservation Optimization Standard for Savings in Federal Residences* means the computerized calculation procedure that is used to establish an energy consumption goal for the design of Federal residential buildings.

(h) *COSTSAFR* means the Conservation Optimization Standard for Savings in Federal Residences.

(i) *DOE* means U.S. Department of Energy.

(j) *Domestic hot water (DHW)* means the supply of hot water for purposes other than space conditioning.

(k) *Energy conservation measure (ECM)* means a building material or component whose use will affect the energy consumed for space heating, space cooling, domestic hot water or refrigeration.

(l) *Energy performance standard* means an energy consumption goal or goals to be met without specification of the method, materials, and processes to be employed in achieving that goal or goals, but including statements of the requirements, criteria evaluation methods to be used, and any necessary commentary.

(m) *Federal agency* means any department, agency, corporation, or other entity or instrumentality of the executive branch of the Federal Government, including the United States Postal Service, the Federal National Mortgage Association, and the Federal Home Loan Mortgage Corporation.

(n) *Federal residential building* means any residential building to be constructed by or for the use of any Federal agency in the Continental U.S., Alaska, or Hawaii that is not legally subject to state or local building codes or similar requirements.

(o) *Life cycle cost* means the minimum life cycle cost calculated by using a methodology specified in subpart A of 10 CFR part 436.

(p) *Point system* means the tables that display the effect of the set of energy conservation measures on the design energy consumption and energy costs of a residential building for a particular location, building type and fuel type.

(q) *Practicable optimum life cycle energy cost* means the energy costs of the set of conservation measures that has the minimum life cycle cost to the Federal government incurred during a 25 year period and including the costs of construction, maintenance, operation, and replacement.

(r) *Project* means the group of one or more Federal residential buildings to be built at a specific geographic location that are included by a Federal agency in specifications issued or used by a Federal agency for design or construction of the buildings.

(s) *Prototype* means a fundamental house design based on typical construction assumptions. The nine prototypes in COSTSAFR are: single-section manufactured house, double-section manufactured house, ranch-style house, two-story house, split-level house, mid-unit apartment, end-unit apartment, mid-unit townhouse, end-unit townhouse.

(t) *Residential building* means a new building that is designed to be constructed and developed for residential occupancy.

(u) *Set of conservation options* means the combination of envelope design and equipment measures that influences the long term energy use in a building designed to maintain a minimum of ventilation level of 0.7 air changes per hour, including the heating and cooling equipment, domestic hot water equipment, glazing, insulation, refrigerators and air infiltration control measures.

(v) *Shading coefficient* means the ratio of the heat gains through windows, with or without integral shading devices, to that occurring through unshaded, ⅛-inch clear glass.

(w) *Total annual coil load* means the energy for space heating and/or cooling with no adjustment for HVAC equipment efficiency.

[56 FR 3772, Jan. 31, 1991]

§ 435.303 Requirements for the design of a Federal residential building.

(a) The head of each Federal agency responsible for the construction of Federal residential buildings shall establish an energy consumption goal for each building to be designed or constructed by or for the agency.

(b) The energy consumption goal for a Federal residential building shall be a total point score derived by using the micro-computer program and user manual entitled ''Conservation Optimization Standard for Savings in Federal Residences (COSTSAFR),'' unless the head of the Federal agency shall establish more stringent requirements for that agency.

(c) The head of each Federal agency shall adopt such procedures as may be necessary to ensure that the design of a Federal residential building is not less energy conserving than the energy consumption goal established for the building.

§ 435.304 The COSTSAFR Program.

(a) The COSTSAFR Program (Version 3.0) provides a computerized calculation procedure to determine the most effective set of energy conservation measures, selected from among the measures included within the Program that will produce the practicable optimum life cycle cost for a type of residential building in a specific geographic location. The most effective set of energy conservation measures is expressed as a total point score that serves as the energy consumption goal.

(b) The COSTSAFR Program (Version 3.0) also prints out a point system that identifies a wide array of different energy conservation measures indicating how many points various levels of each measure would contribute to reaching the total point score of the energy consumption goal. This enables a Federal agency to use the energy consumption goal and the point system in the design and procurement procedures so that designers and builders can pick and choose among different combinations of energy conservation measures to meet or exceed the total point score required to meet the energy consumption goal.

(c) The COSTSAFR Program (Version 3.0) operates on a micro-computer system that uses the MS DOS operating system and is equipped with an 8087 coprocessor.

(d) The COSTSAFR Program (Version 3.0) may be obtained from:

National Technical Information Service; Department of Commerce; Springfield, Virginia 22161; (202) 487-4600

[53 FR 32545, Aug. 25, 1988, as amended at 56 FR 3772, Jan. 31, 1991]

§ 435.305 Alternative compliance procedure.

(a) If a proposed building design includes unusual or innovative energy conservation measures which are not covered by the COSTSAFR program, the Federal agency shall determine whether that design meets or exceeds the applicable energy consumption goal in compliance with the procedures set forth in this section.

(b) The Federal agency shall determine the estimated discounted energy cost for the COSTSAFR prototype building design, which is the most similar of the COSTSAFR prototypes to the proposed building design, by—

(1) Printing out the COSTSAFR compliance forms for the prototype showing the points attributable to levels of various energy conservation measures;

(2) Calculating the estimated unit energy cost on the compliance forms, on

the basis of selecting the optimum levels on the compliance forms or otherwise in the User's Manual for each energy conservation measure; and

(3) Multiplying the estimated unit energy cost by 100.

(c) The Federal agency shall determine the estimated discounted energy cost for the proposed building design by—

(1) Estimating the heating and cooling total annual coil loads of the proposed building design with the DOE 2.1C computer program on the basis of input assumptions including—

(i) Shading coefficients of 0.6 for summer and 0.8 for winter;

(ii) Thermostat setpoints of 78 degrees Fahrenheit for cooling, 70 degrees Fahrenheit for heating (6 am to 12 midnight), and 60 degrees Fahrenheit for Night Setback (12 midnight to 6 am, except for houses with heat pumps);

(iii) The infiltration rate measured in air changes per hour as calculated using appendix B of the COSTSAFR User's Manual;

(iv) Natural venting with a constant air change rate of 10 air changes per hour—

(A) When the outdoor temperature is lower than the indoor temperature, but not above 78 degrees Fahrenheit; and

(B) When the enthalpy of the outdoor air is lower than the indoor air.

(v) Internal gains in accordance with the following table for a house with 1540 square feet of floor area, adjusted by 0.35 Btu/ft^2/hr to account for changes in lighting as the floor area varies from 1540 square feet—

TABLE 1—INTERNAL GAIN SCHEDULE (BTU)

Hour of day	Sensible	Latent
1	1139	247
2	1139	247
3	1139	247
4	1139	247
5	1139	247
6	1903	412
7	2391	518
8	4782	1036
9	2790	604
10	1707	370
11	1707	370
12	2277	493
13	1707	370
14	1424	308
15	1480	321
16	1480	321
17	2164	469
18	2334	506
19	2505	543
20	3928	851
21	3928	851
22	4101	888
23	4101	888
24	3701	802

(vi) Thermal transmittances for building envelope materials measured in accordance with applicable ASTM procedures or from the ASHRAE Handbook;

(vii) Proposed heating and cooling equipment types included in COSTSAFR or having a certified seasonal efficiency rating;

(viii) Weather Year for Energy Calculations (WYEC) weather year data (WYEC data are on tapes available from ASHRAE, 1791 Tullie Circle, N.E., Atlanta, Georgia 30329), or if unavailable, Test Reference Year (TRY) weather data (obtainable from National Climatic Data Center, 1983 *Test Reference Year,* Tape Reference Manual, TD–9706, Asheville, North Carolina) relevant to project location.

(2) Estimating the discounted energy cost for the heating and cooling energy loads, respectively, according to the following equation—

$$\text{Discounted Energy Cost} = \frac{\text{Total Annual Coil Load} \times \text{Fuel Cost} \times \text{UPW*}}{\text{Equipment Efficiency}}$$

Where:

Total Annual Coil Load=the total heating or cooling annual coil load calculated under paragraph (c)(1);

Fuel Cost=the heating or cooling fuel cost calculated in accordance with sections 3.3.D and 3.3.E of the User's Manual;

UPW*=the uniform present worth discount factor; selected from the last page of the compliance forms.
Equipment Efficiency=the test seasonal efficiency rating of the heating and cooling equipment only (i.e., not including duct or distribution system losses).

(3) Estimating the discounted energy cost for water heating and refrigerator/freezer energy consumption—

(i) For equipment types covered by the COSTSAFR compliance forms, by multiplying the estimated unit energy cost by 100; or

(ii)For equipment types not covered by COSTSAFR—

$$\text{Discounted Energy Cost} = \frac{\text{Annual Energy Consumption} \times \text{Fuel Cost} \times \text{UPW*}}{\text{Energy Factor}}$$

Where:
Fuel Cost and UPW* are as defined in paragraph (c)(2) of this section; Annual Energy Consumption is as calculated in 10 CFR 430.22; and Energy Factor is the measure of energy efficiency as calculated under 10 CFR 430.22

(iii) [Reserved]

(4) Adding together the discounted energy costs calculated under paragraphs (c)(2) and (c)(3) of this section;

(d) If the discounted energy cost of the proposed building design calculated under paragraph (c)(4) of this section is equal to or less than the discounted energy cost of the COSTSAFR prototype building design calculated under paragraph (b) of this section, then the proposed building design is in compliance with the applicable energy consumption goal under this part.

[56 FR 3772, Jan. 31, 1991]

§ 435.306 Selecting a life cycle effective proposed building design.

In selecting between or among proposed building designs which comply with the applicable energy consumption goal under this part, each Federal agency shall select the design which, in comparison to the applicable COSTSAFR prototype, has the highest Net Savings or lowest total life cycle costs calculated in compliance with subpart A of 10 CFR part 436.

[56 FR 3773, Jan. 31, 1991]

PART 436—FEDERAL ENERGY MANAGEMENT AND PLANNING PROGRAMS

Subpart A—Methodology and Procedures for Life Cycle Cost Analyses

Subpart B—Methods and Procedures for Energy Savings Performance Contracting

Subparts C—E [Reserved]